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Editorial

Welcome to World Journal of Laparoscopic Surgery.

Reflecting on the activities of World Association of Laparoscopic Surgeons, all of us were privileged to experience in the past from participating in 3rd World Congress of Laparoscopic Surgeons held in Gurgaon on 14th and 15th of February 2012. I am thankful for having an opportunity to learn, for meeting amazing surgeons and gynecologists from more than 35 countries, and for gaining an appreciation for the world of laparoscopy from many different points of views.

Emerging from this appreciation is the concept on creating awareness that even though participating in live robotic and advanced laparoscopic surgery can be very rewarding and fun.

There are many organizations that for years, and they continue to do so, have worked hard advocating for advancement of minimal access surgery. But, I think maybe it's time for not only organizations but also for every individual surgeon to be involved with this cause.

In present era, minimal access surgery is a necessity not luxury and World Journal of Laparoscopic Surgeons focuses on recent advances and prevention of complications of MIS, and help us to become safe surgeon and skilled surgeon. It serves the worldwide community in general to cover information about minimal access surgery. The mission is to educate, inform, have knowledge and save lives, by producing a unique and high-quality journal to further educate and create awareness for the physicians to be involved in minimal access surgery.

I want to welcome you and invite you to join us in this cause, visit our online journal regularly, tell a friend, get involved, send us feedback, submit articles, share your knowledge or share with us who is making a difference in doctors communities and around the world.

RK Mishra
Editor-in-Chief

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ORIGINAL RESEARCH

Laparoscopic Decortication of Simple Renal Cyst with Omental Wadding Technique: Single Center Experience

M El-Shazly, A Allam, B Hathout

ABSTRACT

Objectives: The aim is to study the outcome of laparoscopic decortication of symptomatic simple renal cyst with omental wadding technique in a single center.

Methods: This is a retrospective study of 16 consecutive patients who underwent transperitoneal laparoscopic decortication of symptomatic simple renal cyst with omental wadding technique between November 2007 and November 2011. The indication for surgery was for relief of pain in all cases. Pain was assessed preoperatively and 1 and 6 months postopertively using numerical rating pain scale. All cysts were more than 10 cm in its greatest dimension. Laparoscopic decortication was the primary treatment in 13 cases and the secondary treatment in three cases after sclerotherapy. We used the omental wadding technique to decrease the incidence of recurrence. We reviewed the preoperative and postoperative data.

Results: The operation was successfully completed laparoscopically in all cases with a mean operative time of 95 minutes without major perioperative complications. Hospital stay was 2.4 days (range, 2 to 4 days). Fifteen cases improved significantly after operation in a mean follow-up of 1.5 year. One case only had radiological recurrence after 6 months postoperatively.

Conclusion: Laparoscopic decortication of large simple renal cysts is an efficacious, safe and less invasive method of treatment. Omental wadding is helpful to decrease the incidence of cyst recurrence. Laparoscopic decortication is recommended as a primary treatment for huge cysts or as a secondary treatment after treatment failure with sclerotherapy.

Keywords: Renal cyst, Decortication, Laparoscopic, Omental wadding.

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INTRODUCTION

It is estimated that the incidence of renal cysts is 20% at 40 years of age and 33% at 60 years population.[1] Most of renal cysts are asymptomatic, the diagnosis is usually incidental during abdominal ultrasonography. Up to 5 to 10% of renal cysts are symptomatic. The main presentation is flank pain, occasionally patients may present with hematuria, hypertension or UTI.[2-4]

A simple benign cyst (Bosniak I) has a thin wall without septations, calcification or solid components. Its density measures like water and does not show enhancement with contrast material.[5]

Most of simple renal cysts require no treatment, intervention is indicated only when patients present with symptoms or complications, such as UTI or upper urinary tract obstruction. Sclerotherapy is the ideal primary management especially for relatively small simple renal cysts (less than 10 cm in its greatest dimension). It is a minimally invasive and safe procedure and it is frequently performed to treat these patients. However, the recurrence rate after simple aspiration alone is 41 to 78%. Recurrence rate is around 43% after single session of sclerotherapy and is lowered to 5% after repeated sessions of sclerotherapy.[6-9]

Since, the introduction of laparoscopy to urologic surgery in the 1990s, laparoscopic decortication of simple renal cysts has been reported to be an excellent modality of management as it is effective and it can duplicate techniques of open surgery. This is together with the generic advantages of laparoscopy; less invasive, less morbidity, less pain and less analgesic use, short convalescence and rapid return to work.[10]

PATIENTS AND METHODS

Sixteen patients with simple renal cysts were admitted to Urology Department, Farwaniya Hospital, between November 2007 and November 2011 and mean age 52 years, range 27 to 68; seven males and nine females.

All cases were presented with pain. Pain was assessed using numerical rating pain scale preoperatively and postoperatively after 1 month and 6 monthly. Abdominal ultrasonography and computed tomography with contrast were performed for all cases preoperatively to assess type of cyst and to rule out any connection to pelvicalyceal system. All cases were diagnosed with symptomatic simple renal cyst (Bosniak 1 and 2). The estimated mean largest cyst dimension measured by CT was 14.5 cm (range from 11-19 cm). Fourteen cases had single cortical cyst, and two had more than one cyst. There were no parapelvic cysts in our series.

Ultrasonography was repeated 1 and 6 months postoperatively. CT was repeated postoperatively if ultrasonography suggested the possibility of recurrence.

TECHNIQUE

Under general anesthesia, patients were positioned in the lateral position. Transperitoneal access was established using veress needle or open (Hasson technique). Primary port (10 mm) was inserted on the lateral border of rectus abdominis muscle opposite the umbilicus. Two working ports (5 mm) were inserted after establishment of pneumoperitoneum on the anterior axillary line: One just below the costal margin and the other just above anterior superior iliac spine. Longitudinal incision was done in the posterior peritoneum on the line of Toldt followed by medialization of ascending or descending colon using scissor and Maryland dissector. Gerota's fascia was then dissected to expose the kidney. Aspiration of the cyst was done using aspiration needle inserted through skin under laparoscopic guidance. Excision of the cyst wall (unroofing) was then done. Cauterization of the edges and wadding the cavity with omentum was performed to decrease the possibility of recurrence. Omentum was fixed to the cyst edges with intracorporeal sutures and clips. A drain is left for 1 day only. Removal of ports and closure of port sites were performed.

RESULTS

The demographics and operative data are summarized in Table 1.

The operation was successfully completed laparoscopically in all cases with no conversion to open surgery. There were no major perioperative complications. One case only developed ileus postoperatively and stayed for 4 days. This was due to some colonic adhesions that required more dissection. Hospital stay was 2.4 days (range, 2 to 4 days). The mean blood loss was 50 ml (range 60-135 minutes). Fifteen cases improved significantly after operation in a mean follow-up of 1.5 years. One case had recurrence after 6 months. Unfortunately, he developed colon cancer and refused any further intervention.

Table 1: The demographics and operative data

Demographics and operative data	*Results*
Mean age (range)	52 years (range 27-68 years)
Males	7
Females	9
Cyst size (mean largest dimension of cyst)	14.5 (range 11-19 cm)
Approach	All transperitoneal
Mean operative duration	95 minutes (range 60-135 minutes)
Mean blood loss	50 ml (range 30-80 ml)
Mean hospital stay (range)	2.4 days (range 2 to 4 days)
Recurrence	1

The mean numerical pain score was 5.5 preoperatively and decreased to 0.5 after 1 month postoperatively. After 6 months, the mean numerical pain score was 1.7. This was statistically caused by the occurrence of recurrence in one case after 6 months.

The mean operative time was 95 minutes (range 60-135). The mean operative duration for the three cases that had sclerotherapy prior to laparoscopic decortication was 115 minutes. The mean operative duration of the thirteen cases that had laparoscopic decortication as a primary management was 72 minutes. The difference is statistically significant using Statpac version III (using t-test: t was 5.2, degree of freedom 14, two tailed probability 0.0001).

DISCUSSION

Renal cysts can be classified to simple (Bosniak type I and II) or complex (Bosniak type III and IV) cysts with risk of malignancy according to Bosniak classification.[11]

The ideal management of symptomatic simple renal cyst should be less invasive and effective with low recurrence rate. Aspiration only or aspiration sclerotherapy is less invasive, however the recurrence rate is relatively high.[6,7]

Open surgery offers the best success rate and lowest recurrence rate among the different modalities; however, it is invasive procedure with the comorbidities of flank incision. Laparoscopy offers effective treatment with high success rate and low recurrence rate comparable to open surgery with the advantage of being less invasive modality of management.[9,10]

Different laparoscopic techniques are reported: Simple decortication using monopolar diathermy or scissors, marsupialization, decortication with omental wadding and different approaches; transperitoneal, extraperitoneal and less have been described.[12,13]

Inspite of the advancement of different laparoscopic techniques, the reported recurrence rate is still up to 19% regardless the technique used.[14]

Transperitoneal and retroperitoneal approaches are comparable regarding to improvement of pain, clinical success and radiological findings. Transperitoneal approach has the advantages of larger working space, anatomical landmarks and has the disadvantages of longer operative duration and need to mobilize colon.[15] We preferred the transperitoneal approach as it is our preferred approach and it allows accessibility to the omentum for decortication with omental wadding.

Recurrence after laparoscopic decortication could be explained by incomplete resection of the cyst wall. The residual secreting cyst wall can become adherent to surrounding tissues with development of a new cyst. To prevent recurrences, different techniques have been reported, i.e. cyst decortication with fulguration of the cyst base, marsupialization, resection with surgical bolsters positioned into the base of the cyst, and omental wadding of the cyst.[16,17]

After the second case that got recurrence after 6 months, we started to ensure complete excision of the cyst wall and to wad the floor of the cyst with omentum and fix it with clips. We did not have any recurrence with this technique. This agrees with other series reporting less recurrence rate with this technique.[2]

We encountered some difficulties in dissection of the Gerota's facia and excision of cyst wall in our three cases that had sclerotherapy. This can explain the longer mean operative duration in these cases.

CONCLUSION

Laparoscopic decortication of large simple renal cysts is an efficacious, safe and less invasive method of treatment. Omental wadding is helpful to decrease the incidence of cyst recurrence. Laparoscopic decortication is recommended as a primary treatment for huge cysts or as a secondary treatment after treatment failure with sclerotherapy.

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ORIGINAL RESEARCH

The Role of Thoracoscopy in Diagnosis and Treatment of Pleural Disease

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ABSTRACT

Intrathoracic disease involving lungs and pleura encountered frequently and remains a challenging clinical problem.

The definitive diagnosis of lung or pleural disease some times remain unclear despite thoracocentesis, closed pleural biopsy, transthoracic needle aspiration or bronchoscopy. Recent advances in endoscopic technique, video equipment and development of better instrumentation have contributed to the resurgence of thoracoscopy as a diagnostic and thoracoscopic modality.

Keywords: Malignancy, Needle biopsy, Pleural disease, Thoracoscopy, Tumor.

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INTRODUCTION

Thoracoscopic surgery of the chest using a simple rigid scope was first described in terms of its original concept in 1910 by Dr Jacobaeus,[1] a Swedish internist. It proved to be safe and diagnostically accurate. Its major use subsequently was in the era of collapse therapy with lysis of pleuropulmonary adhesions for tuberculosis treatment.[2] With the development of antituberculous drugs in the late 1940s, thoracoscopy was all but abandoned except for diagnosing pleural disease. In 1970, Dr Joe Miller, Jr, at the Emory Clinic, began to match changes in technology with clinical applications and the thoracoscopy has reemerged as an alternative approach to open thoracotomy in the management of chest disease. Minimally invasive thoracic surgery allows the performance of surgical procedures in the chest cavity utilizing small incisions and specially-adapted, video-endoscopic instruments. This affords a quicker and less painful convalescence for the patient. Many procedures which were previously performed with larger incisions can now be done thoracoscopically, with comparable results. Thoracoscopy is useful for the diagnosis and treatment of a variety of intrathoracic processes, such as for solitary pulmonary nodule resection, metastatic resections, open lung biopsies, pericardiectomies, pneumothorax repair, resection of small mediastinal tumors; lung-volume reduction for pulmonary emphysema and pleural space drainage procedures. It has become an alternative approach for sympathectomy for upper extremity hyperhidrosis, sympathetic dystrophy and Raynaud's phenomenon.[3] Good short-term results are reported for achalasia via thoracoscopic esophagomyotomy.[4] Indeed, the indications for VATS continue to evolve.[3-6]

Although thoracoscopy is used for such procedures, adequate controlled trials confirming its superiority to conventional open thoracotomy are lacking. Its evaluation has been based on performance in selected patients by experienced operators. In this review, we discribed the thoracoscopy's technique, advantages, disadvantages, diagnostic utility, therapeutic and operative applications, complications and controversies.

Finally, a few thoughts about future directions of this emerging technology are shared.

PROCEDURE DETAILS

Simple rigid thoracoscopy (without video assistance) must be differentiated from VATS (with video assistance). Simple rigid thoracoscopy is the use of a metal, illuminated scope placed into the pleural space for the purpose of diagnosing pleural disease or performing minor therapeutic maneuvers such as pleurodesis. Video equipment is not used. Operators can use a lighted mediastinoscope, thoracoscope, or laparoscope. The mediastinoscope offers a large working channel and provides for excellent visualization of the pleural space. Simple rigid thoracoscopy can be performed under local anesthesia in an endoscopy suite or under general anesthesia in an operating room.

For simple rigid thoracoscopy, the patient is prepared and draped in the lateral position with the affected side upward. The entry point is usually between the third and sixth intercostal space along the midaxillary line, depending on the indication.

Video-assisted thoracoscopic surgery (VATS) primarily used by thoracic surgeons, VATS is a surgical technique used to potentially minimize the morbidity of an open procedure.

The thoracoscope consists of a slender fiberoptic tube that can be inserted into a 1/2 inch incision in the chest. The image is then combined with a tiny telescopic lens, a powerful light source, and a small video camera and is projected onto a TV screen. The surgeon can literally see into the chest. Then using graspers, endoscopic scissors and endostaples, the surgeon can perform a whole host of procedures. Recent advances in endoscopic techniques, surgical instrumentation, and air-tight endostaplers have contributed to the resurgence of thoracoscopy as a useful diagnostic and therapeutic modality.

Certain VATS procedures can be performed under local anesthesia, but VATS typically requires general anesthesia and is performed in an operating room. Operators commonly employ the double-lumen endotracheal tube or bronchial blocker for selective lung ventilation.

Thoracoscopy is usually performed through one or several small, less than 2 cm skin incisions made along the intercostal spaces. Patients are placed in the lateral decubitus position, involved side up, although some procedures, such as a thoracic sympathectomy, are performed with patients in the supine position. Pleural trocars can also be safely placed in the axilla, so that axillary thoracotomy IV sedation and local anesthesia are administered using techniques similar to those employed when making a chest tube insertion incision. Many operators prefer general anesthesia with single- or double-lumen endotracheal intubation performed in an operating suite. Certainly, the operating room is the accepted procedural area for diagnostic and therapeutic procedures such as lung biopsies, decortication, or cardiovascular interventions.

Many procedures limited to removal of pleural fluid, visualization, and biopsy of parietal pleura can be performed through a single skin incision made in approximately the fifth to seventh intercostal space along the lateral chest wall of the involved hemithorax. When a 5 to 10 mm pleural trocar and cannula are interted through the incision, the parietal pleura, diaphragm, and lung are well visualized. Pleural fluid is evacuated and parietal pleural biopsy specimens are obtained from both normal- and abnormal-appearing areas. A chest tube is placed through the incision site and connected to a suction device, and the lung is gently reexpanded. Because the duration of chest tube drainage can be only a few hours, many patients are discharged the same day. In years past, this type of procedure was commonly referred to as pleuroscopy. Today, because of the very minimally invasive nature of the procedure, it has become known as 'medical thoracoscopy'.[3] Complications such as bleeding (from parietal pleural biopsy), lung perforation (during trocar insertion), or infection (from inadvertently using nonsterile techniques) are extremely rare.[4]

Advanced diagnostic and therapeutic procedures are usually performed in an operating suite. Multiple incisions allow the introduction of biopsy forceps, endoscopic scissors, electrocautery, suction-irrigation instruments, and grasping forceps to allow greater mobilization of the lung, removal of fibrin deposits or blood clots, and sectioning of adhesions that prevent complete inspection of the pleural space and mediastinum. Sometimes these adhesions also inhibit complete lung expansion; they may also maintain patency of visceral pleural tears in patients with spontaneous or secondary pneumothorax. In patients with complex pleural effusions, suspected underlying trapped lung requiring an attempt at reexpansion using positive pressure ventilation, empyema, and multiloculated pleural effusions from infection or malignancy, the pleural space and mediastinum can be safely explored using general anesthesia and multiple access sites. Although comparative studies have not been performed, it is possible that complication rates may be increased in this setting because of the increased morbidity of patients undergoing these procedures, the use of general anesthesia and the invasive scope of procedures being performed.

Advantages and Disadvantages of Thoracoscopy

Advantages

Thoracoscopy offers the several advantages over more conventional techniques; namely, it (1) potentially permits access to the entire pleural cavity, including both the parietal and visceral pleura, (2) allows for directly visualized biopsies, certainty of representative tissue for diagnosis, and (3) affords control of bleeding, (4) lysis of adhesions allow inspection, (5) recovery time from surgery (shorter hospital stays and a shorter duration of chest tube drainage compared with thoracotomy)[42] and the level of pain experienced by the patient is markedly reduced. Lastly,[6] the small incisions used are better tolerated than the old larger open thoracotomy incisions.

Potential advantages of thoracoscopy over more conventional techniques include certainty of representative tissue for diagnosis, reduced requirements for postoperative analgesia, shorter hospital stays, and a shorter duration of chest tube drainage compared with thoracotomy.[42]

Disadvantages

1. Invasive procedure
2. Cost
3. Loss of bimanual palpation of the lung
4. Loss of binocular vision
5. Moreover, 20% of VATS procedures require conversion to thoracotomy, which can add operative time and cost.[7]

DIAGNOSTIC THORACOSCOPY

Pleural effusions: Algorithms for investigating pleural effusion of unknown etiology typically begin with thoracentesis percutaneous closed pleural biopsy. Thoracoscopy is often performed because these procedures are nondiagnostic. Cytologic analysis of thoracentesis fluid is positive in 45 to 80% of malignant pleural effusions; however, it is positive in as few as 20% of patients with mesothelioma.[2,12-17] Repeated thoracentesis for cytologic analysis provides limited increases in yield (17 to 22% additional yield for malignancy).[14,18] Thus, closed pleural biopsy in addition is advocated by some authors to further increase the diagnostic yield.[18]

Closed pleural biopsy is reported to be diagnostic for pleural malignancy in approximately 50% of cases.[16,17] A large retrospective study by Prakash[17] involving 414 patients with pleural effusion found malignant disease in 281 (68%) patients. Fluid cytologic study was positive in 163 (58%), closed pleural biopsy positive in 121 (43%), either positive in 183 (65%). However, in only 20 (7%) of the 281 patients with malignant effusion, closed biopsy specimens revealed malignant disease when the fluid cytologic study was negative. This study is often cited as an indication not to do initial concurrent thoracentesis and closed pleural biopsy when malignancy is the primary consideration. If the initial thoracentesis fluid is an exudate, with cytologic study negative for malignancy, it seems reasonable to then repeat thoracentesis with the addition of a closed pleural biopsy. In contrast, it is recommended that thoracentesis and closed pleural biopsy both be performed initially if tuberculosis is the primary consideration because the combined sensitivity for tuberculosis by thoracentesis culture and closed pleural biopsy is greater than 80%.[17,19] Normal findings from thoracentesis and closed pleural biopsy, however, give no assurance that malignancy is absent.

Boutin et al[14] noted three limitations of thoracentesis and closed needle biopsy in evaluating malignant effusions: (1) False-positive cytologic results range from 0.5 to 1.5%; (2) characterizing the type and origin of the cancer is difficult; and (3) the sensitivities depend directly on the stage of the cancer. Moreover, closed needle biopsy is effective in adequately sampling the parietal pleura in only 75% of attempts.[19] Rodriguez-Panadaro et al,[20] by studying 191 autopsies, added that the parietal pleura is less frequently involved with metastatic pleural disease than the visceral pleura. Localized and diaphragmatic tumors are often not even accessible by closed needle biopsy. The above limitations account for some of the reduced diagnostic efficacy of thoracentesis and closed needle biopsy for malignancy.

Despite extensive conventional evaluation, 10 to 27% of patients with pleural effusions remain without a specific diagnosis.[2,4,17,21,22] One third to half of these effusions may ultimately be diagnosed as malignant.[2] Contrary to thoracocentesis and percutaneous CPB, thoracoscopy permits biopsy with direct visualization.[6] Thoracoscopy is commonly performed after one or two thoracocenteses and at least one nondiagnostic closed pleural biopsy.

Thoracoscopy, using either simple rigid or VATS, has very high sensitivity (80 to 100%) for both benign and malignant pleural disease.[2,9,13,14,23-26] Thoracoscopy increases diagnostic yield for effusions after thoracentesis and closed pleural biopsy specimens are nondiagnostic. Thoracoscopy also yields few false-negative results. Boutin et al[14] retrospectively analyzed 215 simple rigid thoracoscopies for EUO. Thoracoscopy successfully identified 131 of 150 (87%) malignant cases whereas repeated pleural cytologic study and closed needle biopsy specimens the day before surgery yielded positive results in only 62 of 150 (41%) malignant cases. Thoracoscopy gave positive results in 63 of 75 (84%) patients with malignancy who had at least two previous negative cytologic specimens and one or more negative closed needle biopsy specimens.[15] Hariis et al[15] reported thoracoscopy had a diagnostic sensitivity of 95% for pleural malignancy and 100% for benign disease. Importantly, malignancy was demonstrated by thoracoscopy in 24 of 35 (69%) patients who had two negative preoperative pleural cytologic specimens and in 27 of 41 (66%) patients who had a preoperative nondiagnostic closed pleural biopsy specimen.

However, limitations in the published literature exist regarding thoracoscopy and its utility in the management of pleural disease. First, most of the studies show a selection bias toward including patients with known malignancy or a high pretest likelihood of malignancy, thereby improving the sensitivity of thoracoscopy.[3,4] Several studies report a high number of mesothelioma cases.[2,5] Data obtained from such studies may not be applicable to an unselected population with EUO. Second, in four series reporting a diagnostic accuracy of 90 to 100%, follow-up was either not stated or lasted less than 6 months.[3-6] In three series in which a total of 822 patients were followed-up for 1 to 5 years, accuracy was only 62 to 85%.[7-9] Third, it is unclear if the benefits of an earlier diagnosis and the clinical certainty of pleural malignancy warrant the costs of the procedure and its potential morbidity. Thus, many questions still remain regarding the selection of patients for thoracoscopy, its timing, and its true impact on the management and outcome of pleural disease.

Tuberculous Pleurisy

The greater debate is whether thoracoscopy is warranted, if tuberculosis is high on the list of differential diagnoses.

In exudative pleural effusions due to tuberculosis, the diagnostic yield of a closed needle biopsy is 70 to 90%. Thoracoscopy is usually unnecessary, therefore, to establish the diagnosis of a tuberculous effusion. A combined yield of only 6% for thoracoscopy preceded by negative thoracentesis and closed needle pleural biopsy has been reported. Thoracoscopy may be beneficial in difficult diagnostic situation, however, when lysis of adhesions is necessary, or when larger amounts of tissue are warranted to assure diagnosis when drug resistance is suspected.

Malignant mesothelioma: Although malignant mesothelioma may be suspected based on a history of asbestos exposure, symptoms, radiographic findings of pleural fluid, thickening, absence of contralateral shift of the mediastinum, and clinical course; diagnostic confirmation is often difficult. The diagnosis of mesothelioma depends foremost on histologic findings.[29] Pleural fluid cytology ranges from 4 to 77%, and representative specimens from closed needle biopsy are rarely of sufficient size and number to allow the full battery of immunohistochemical stains and electron microscopic examination for definitive diagnosis.[7] Obtaining definitive biopsy samples for the diagnosis of mesothelioma is a main indication for thoracoscopy. Even with thoracoscopy, the accuracy of diagnosing mesothelioma may suffer because of inadequate visualization due to extensive adhesions and the inherent difficulties in pathologic identification of this tumor.[8] Thoracoscopy allows removal of large, full-thickness specimens from several involved areas, making it potentially preferable to open pleural biopsy by minithoracotomy, and most certainly preferable to lateral thoracotomy. For patients not considering intrapleural chemotherapy or surgical resection, pleurodesis can be performed at the time of diagnostic thoracoscopy in order to prevent fluid reaccumulation and to delay the onset of life-threatening dyspnea. Although tumor growth through thoracoscopic incision sites has been described,[9] it is probably less frequent than reported. Prevention is possible by treating the area surrounding the incision sites with radiation. Boutin et al[30] recently reviewed the results of simple rigid thoracoscopy in 153 patients with malignant mesothelioma. The main indications were chronic pleurisy (88%) and radiologically detected pleural densities (9%). One quarter of the patients required electrocautery or laser to lyse adhesions. Thoracoscopic biopsy specimens were positive in 150 of 153 (98%) mesothelioma cases. In contrast, the combined sensitivity of pleural cytologic study and closed needle biopsy was only 38%. Thoracoscopy provides equally good tissue samples for diagnosis of mesothelioma compared with thoracotomy?[31] Thoracoscopy also allows accurate staging of mesothelioma, so an unnecessary thoracotomy can be avoided.

Parenchymal Disease

Ultimately, one-third of patients with diffuse lung disease will undergo open biopsy to establish a diagnosis.[32] Open lung biopsy has an operative mortality of 1.7% and risk for serious morbidity of 2.5% in selected patients.[14,33] Thoracoscopic lung biopsy has been proposed as an alternative to open biopsy when bronchoscopic transbronchial biopsy specimens are indeterminate. Thoracoscopy, as opposed to bronchoscopy, can obtain larger pieces of lung tissue under direct visualization.

In addition, it provides tissue for mineralogic studies of the pneumoconioses, and for diagnosis of pulmonary infiltrates or peripheral nodular lesions of unknown etiology. Specimens are usually obtained using an endoscopic stapling device. VATS is now another alternative to open lung biopsy. Various nonrandomized studies have investigated the VATS approach for lung biopsy. Bensard et al[36] retrospectively analyzed 22 consecutive patients with interstitial disease who underwent VATS lung biopsy and compared then with 21 control patients who underwent open biopsy. They concluded that VATS (1) provided equivalent specimen volume, (2) achieved equal diagnostic accuracy, and (3) reduced both the time for pleural drainage and the length of hospital stay. Ferson et al[37] retrospectively compared 47 patients who underwent VATS lung biopsy with 28 historical control patients who underwent open wedge biopsy via limited thoracotomy. The mean operative time was significantly longer in the VATS group (69 *vs* 93 minutes respectively), but there were significantly more complications in the open group (including more bleeding and prolonged air leaks). The duration of hospital stay was shorter in the VATS group (mean, 4.9 to 12.2 days).

The above studies suggest that VATS lung biopsy is an alternative to open biopsy. VATS lung biopsy is suitable for patients in stable condition who are not requiring mechanical ventilation. Ventilator-dependent patients should not undergo biopsies by the VATS approach because they typically cannot tolerate the change to a double-lumen endotracheal tube or the single-lung ventilation technique. For patients requiring mechanical ventilation in most cases, it is advisable to perform an open lung biopsy through an expeditious limited thoracotomy using minimal rib spreading.

A solitary pulmonary nodule (SPN) is a discrete nodule less than 3 cm in diameter that is completely surrounded by lung and is not associated with parenchymal disease or adenopathy.[40] Over 80 different causes have been reported.[40] Overall, malignant lesions comprise 44% of all SPN, and most (35%) are bronchogenic cancer.[42] The risk of malignancy depends on nodule size, growth rate, patient age, patient smoking exposure and certain radiographic findings.[41-43]

Integrated approaches for the evaluation and management of SPN are described elsewhere.[42-45] Options for managing the SPN include observation, assessment by noninvasive imaging, cytologic or histologic investigation by transthoracic needle biopsy (TTNB) or bronchoscopy, and surgical resection. TTNB has a diagnostic sensitivity ranging from 43 to 97% for malignant lesions but is less effective in yielding a definitive benign diagnosis.[45] But, TRNB is complicated by pneumothorax in approximately 15% of patients.[43-45] It also has a false-positive rate of 1.5 to 3%; the false-negative rate in the presence of malignancy ranges from 3 to 11%.[46-48] Bronchoscopy is useful for larger central lesions but has low diagnostic yield, approximately 10%, for small peripheral lesions.[49,50] If malignancy or a definitive benign diagnosis has not been proved by these less invasive procedures, the SPN can be approached surgically. Mack et al[45] from three collaborative institutions, excised by VATS under general anesthesia undiagnosed selected SPNs in 242 patients. If the nodule was not pleural based or immediately subpleural, preoperative needle localization was used. Wedge excisions were performed using an endostapler alone (72%), a laser (18%), or both (10%). Only two patients required conversion to open thoracotomy because of technical difficulties. A definitive diagnosis was made in every patient. A specific benign diagnosis was obtained in 127 (52%) patients and a malignant diagnosis in 115 (48%). Of the malignant nodules, 51 (44%) were primary lung carcinomas and 64 (56%) were metastases. If the nodule was determined to be a primary lung malignancy, and the patient had adequate pulmonary function (n = 29), an immediate thoracotomy and lobectomy were performed to ensure adequate resection. There was no mortality and the complication rate was 3.6% in the group who underwent thoracoscopy alone. The average hospital stay for the patients who underwent thoracoscopy alone was 2.6 days. Although this report demonstrated 100% diagnostic sensitivity and specificity for an SPN, the exact role and optimal timing of thoracoscopy in the management of SPN is currently not determined.

THERAPEUTIC AND OPERATIVE APPLICATIONS OF THORACOSCOPY

Overview of simple rigid thoracoscopy is still used for effusion management, pneumothorax repair and drainage of uncomplicated empyema or hemothorax. With the development of endostaplers and refinements in instrumentation, thoracic surgeons are also performing VATS procedures for many indications previously reserved for open thoracotomy.

Lung nodules, pleural effusions, and pulmonary infiltrates were the most common indications for VATS procedures. Procedures performed most commonly were wedge resection, pleural biopsy, pleurodesis and lung biopsy. Prolonged air leak was the most common complication.

Current Role of Interventional Thoracoscopy for each of Its Operative Applications

Pleural Applications

Empyema thoracis remains a condition with substantial morbidity and mortality. Selected empyemas can be satisfactorily decompressed with conservative regimens of repeated thoracentesis, or closed tube thoracostomy.[51] More aggressive surgical approaches include open drainage procedures, decortication and thoracoplasty. Recently, thoracoscopy with repeated irrigation of the thoracic cavity has been described. Thoracoscopic success depends on the mechanical removal of infected material and ensuring fun lung reexpansion. Wakabayashi[52] described 20 patients who underwent debridement of chronic empyema by thoracoscopy through a small incision; the lungs reexpanded in 18 (90%). The lung failed to reexpand in two patients, both whom had empyema of more than 4 months' duration. Ridley and Braimbridge[51] reported overall complete resolution of empyema in 18 of 30 (60%) selected patients even though many were investigated at a late stage after initial treatment regimens had failed. Of the 12 patients who did not have complete resolution after thoracoscopy, the empyema resolved in eight (66%) patients after open surgical procedures. Thoracoscopic debridement may provide valuable time to improve the clinical condition of debilitated patients until they can tolerate more aggressive surgical approaches. However, critics have argued that thoracoscopic debridement delays definitive treatment as evidenced by Ridley's 12 (40%) patients who subsequently needed additional surgery after thoracoscopic evacuation failed.[53] Patient selection and the stage of the empyema at intervention are the main determinates of outcome for thoracoscopic debridement of empyema. During the exudative and organizing phase of empyema, thoracoscopic visualization allows debridement of fibrinous adhesions and evacuation of loculated fluid.[32] The timing of thoracoscopic intervention is critical, however, and should be considered when chest tube drainage is unsatisfactory after 3 to 5 days. If thoracoscopy is used, it is important to evacuate the empyema early before adhesions become too dense and an organized 'peel' develops.[29] The use of thoracoscopy for complete debridement, pleurectomy, and decortication for empyema management has yet to be adequately proved. The precise role for thoracoscopy instead of chest tube drainage, instillation of fibrinolytic agents, rib resection, or thoracotomy-decortication is still controversial.

Malignant Pleural Effusions

In addition to diagnosis, an important indication for thoracoscopy in patients with malignant pleural effusions is pleurodesis.[10] Complete evacuation of pleural fluid, maximization of lung expandability by removing adhesions, and pleurodesis by talc insufflation (also known as talc poudrage) results in short and long-term success rates of (is greater than) 90%.[11] Distribution of sterile, asbestos-free, US Pharmacopeia-approved talk powder on all pleural surfaces is confirmed by thoracoscopic visualization. Following pleurodesis, low-grade fevers should be expected in up to 30% of patients, and hospitalization duration averages 4.8 days. Pleurodesis can also be achieved by pleurectomy using standard dissection techniques or hydrodissection.[12] Because survival of patients with advanced pleural carcinomatosis is often short, the risks and benefits of thoracoscopic pleurodesis must be carefully weighed against those of repeated thoracentesis, tube thoracostomy, or bedside pleurodesis through an indwelling chest tube. The talc stimulates an adhesive obliterative pleuritis. Austin and Flye[54] reported an overall 90% effectiveness for talc compared with 87% for tetracycline and 55% for tube thoracotomy alone in malignant pleural effusions. Thus, thoracoscopic tale poudrage is an effective option for managing symptomatic effusions; however, it usually requires general anesthesia in a high-risk population. Talc itself is inexpensive, but the charges for sterilization, general anesthesia, and the operating room can substantially increase the total cost. Talc can be simply administered by slurry through tube thoracostomy, but only a limited number of patients have been studied. Appropriate dosages, measures to ensure complete pleural distribution, and adverse effect profiles for slurry have not been determine.[55] Moreover, talc's overall effect on patient outcome in malignant pleural disease is questionable as evidenced by the poor survival in the patients of Ohri et al.[10] Currently, thoracoscopic talc poudrage is reserved for the selected symptomatic group that does not respond to other agents applied through closed tube thoracostomy.[54,55] It is also performed in those patients with good performance status and a reasonable expected survival.

Recurrent Pleural Effusions of Benign Etiology

Recurrent pleural effusions of benign etiology are frequently caused by heart failure, cardiac surgery, nephrotic syndrome, connective tissue diseases, and other inflammatory disorders. Thoracoscopy may be warranted when recurrent effusions cause symptoms and are not controlled by repeated large-volume thoracentesis. Usually, pleural biopsy specimens are obtained to exclude infectious or neoplastic etiologies, and pleurodesis is performed. Results are usually excellent when talc is used, with success rates varying from 65 to (is greater than) 90%.

Chylothorax

Thoracoscopy has changed diagnostic and therapeutic approaches to patients with chylothorax. Chylothorax is usually caused by trauma or malignancy (primarily lymphoma). Thoracoscopic exploration may precede or replace an open thoracotomy. If the torn thoracic duct is visualized (having the patient drink heavy cream about 1 hour prior to the procedure may facilitate its detection), it can be clipped or ligated endoscopically. Although survival is often limited in case of chylothorax from lymphoma, talc pleurodesis may provide satisfactory resolution of effusions and prevent deterioration of respiratory, nutritional and immunologic status.[18]

Parenchymal Applications

Spontaneous pneumotherax may occur in any individual, including those without existing lung disease. It is almost always caused by the rupture of a subpleural bleb or bullae.[55] The choice of treatment depends on the size, symptoms, presence of continued air leak and the recurrence rate. Small, asymptomatic pneumothoraces in patients with adequate cardiopulmonary reserve may be managed by simple aspiration or observation. If the pneumothorax is large or symptomatic, closed tube thoracostomy is the main therapeutic approach. But with a recurrence rate of 30% after the first episode and even higher for each subsequent recurrence, this may not be effective.[56] Thoracoscopy provides an excellent alternative to repeated chest tube drainage in patients with recurrent or prolonged [usually (is greater than) 5 days] pneumothorax.[24] Thoracoscopy allows definitive treatment or inspection prior to performance of a lateral or axillary thoracotomy.[25] Various thoracoscopic techniques are available to manage spontaneous pneumothorax; namely talc poudrage, laser therapy and stapling. Thoracoscopic findings in patients with spontaneous pneumothorax include normal appearance, pleural adhesions, small blebs [(is less than) 2 cm] on the visceral pleural surface, and large bullae [(is greater than) 2 cm]. Lesions can be removed using electrocautery, argon plasma coagulation, or stapled lung resection, with results that are similar to those obtained after open thoracotomy (although the resulting pleurodesis may be somewhat less effective: Recurrence rates are reportedly 5 to 10% *vs* only 1 to 3% after open thoracotomy.[26] Talc insufflation for pleurodesis may also be effective.[27] Although most operators perform these procedures using general anesthesia, thoracoscopic wedge resection of blebs and bulla using local anesthesia has been reported.[28]

Endoscopic photocoagulation by argon or neodymium: Yttrium-aluminum-gamet (ND:YAG) lasers can be used as curative therapy for pneumothorax. Torre et al coagulated blebs and partially scarred parietal pleura through the thoracoscope in 85 patients with spontaneous pneumothorax. There were no complications despite the use of general anesthesia. The average hospital stay was 5 days. Eighty (94%) patients were treated successfully by thoracoscopy and laser follow-up, 5 to 86 months. Thoracoscopy and laser failed early in two patients; both patients had lesions larger than 2 cm. Three other patients developed a later recurrance of pneumothorax. Each required thoracotomy.

Thoracoscopy, with its various modalities, is successful with a low recurrence rate for spontaneous pneumothorax. Some argue that the indications for operative intervention in the patient with a spontaneous pneumothorax have changed since the advent of the VATS technique.[39] Some surgeons now perform VATS sooner if chest tube thoracostomy is not effective by 72 hours.[39] We have been advocating, for various reasons, earlier surgical intervention for persistent air leak irrespective of which technique is employed. Nevertheless, it is still not clear that thoracoscopy is justified in patients presenting with a first episode of pneumothorax. It is clear that thoracoscopy is best suited for pneumothorax from small, visible blebs, whereas thoracotomy is still the surgical treatment of choice for the patient with known substantial bullous disease.[57]

Pulmonary metastasectomy may favorably influence survival in selected patients with certain tumors.[58,59] There are two patient populations that are considered for metastasectomy. The first group consists of patients who will not achieve a survival benefit from resection but in whom a diagnosis of metastatic disease is needed. The second group consists of those patients with a limited tumor burden who may achieve a survival benefit from metastasectomy. Currently, thoracotomy or median sternotomy are the standard surgical approaches for pulmonary metastasectomy. The operative morbidity varies from 5 to 14% and the hospital stay from 8 to 10 days in recent series using these open approaches.[58,60] Dowling et al[58] successfully performed VATS resection of select peripheral lesions in 72 patients by the use of an endostapler, laser, or both. The mean diameter of the resected lesions was 1.6 cm (range, 0.2 to 4.3 cm). The lesions were resected and each had a tumor-free margin of at least 1 cm. The mean duration of chest tube placement and hospital stay were 2.1 and 4.1 days respectively. Seven patients (10%) experienced a complication (three patients had prolonged air leaks).

There are several limitations to the VATS approach. First, only peripheral lesions are accessible by this technique. Second, the operator cannot perform careful bimanual palpation of the lungs; thus, resection may be incomplete. In a retrospective study, Roth et al[61] noted that 45% of patients with unflateral metastases present on preoperative chest computed tomography were found to have bilateral metastases present at median stemotomy. Confirmation of equivalent survival by randomized trials among the various surgical approaches for metastasectomy is required before the reported reduced morbidity and length of stay afforded by the thoracoscopic technique can be of significant benefit to the patient.

Emphysematous bullae that compromise aerating adjacent lung can adversely affect patients with limited pulmonary reserve. Although some authors advocate surgical management of diffuse emphysematous disease,[11,62] the main indication for operation in patients with bullous emphysema is the presence of giant bullae.[9] Bullectomy may benefit selected patients if the bullae occupy a significant portion of the hemithorax, and the structure and function of the remaining lung parenchyma are preserved. Wakabayashi et al[11] described 22 patients who underwent thoracoscopic ablative bullectomies with the carbon dioxide (CO_2) laser technique. Patients in this study had advanced emphysema with poor lung mechanics (mean forced expiratory volume in 1 second = 26% predicted). Two patients died postoperatively (one myocardial infarction, one pneumonia); thus, the perioperative mortality was nearly 10%. Three (14%) patients required subsequent thoracotomies for complications but did well. All patients reported improved dyspnea postoperatively. Postoperative pulmonary function tests were available at up to 3 months in 11 patients. FEV_1, FVC, and exercise treadmill times increased significantly indicating objective improvement. Nevertheless, an ill-defined patient selection, prolonged air leaks (mean 13 days), insufficient follow-up data, and the high perioperative surgical mortality in this series make thoracoscopic CO_2 laser bullectomy very controversial.

Kaiser[39] performed 23 consecutive VATS bullectomies for giant bullae and had no mortality. All patients reported functional improvement. Long-term outcome remains to be determined, however, the best candidates for bullectomy are those patients with a striking progression in the size of the bullae with a concurrent decrement in pulmonary function over a relatively short period of time.[39] Larger, controlled studies are certainly necessary before thoracoscopic ablation can be advocated for the large number of high-risk patients with emphysematous bullous disease.

Lobectomy for localized lung carcimoma is possible using current VATS technology. Kirby et al[6] described successful VATS lobectomy with lymph node staging in 35 of 41 (85%) study patients. Patients were placed in the lateral position for possible posterolateral thoracotomy. Initially, a thoracoscopy port was placed in the seventh or eighth intercostal space in the anterior axillary line. A zero-degree thoracoscope with a video camera was introduced into the pleural space. A second thoracoscopy port was then placed in the eighth or ninth intercostal space in the posterior axillary line. Next, a 6 cm access minithoracotomy incision was placed just below the tip of the scalpula through which larger thoracic instruments could be introduced into the chest. Whenever possible, a muscle-sparing incision was used. This nonrib spreading access incision allowed for better inspection and palpation of the lung, both of which are limitations of the VATS approach. To ensure proper staging of the lung cancer, multiple biopsy specimens of hilar and mediastinal lymph nodes were obtained, in particular in those few patients who had not undergone a staging mediastinoscopy. This VATS technique also allowed for biopsy specimens of lymph node stations that are not readily accessible by mediastinoscopy. These stations include the posterior subcarinal, paraesophageal hilar and inferior pulmonary ligament nodes. This nonrib spreading access incision also allowed for the safe removal of the resected specimen. The special technical considerations for each lobe resection are available in more detail.[6] Of the 41 patients, no major intraoperative complications occurred. Six (14%) patients required conversion to open thoracotomy because VATS lobectomy proved technically impossible. The 35 patients who underwent VATS had an uneventful recovery with a mean hospital stay of 5.7 days. This study indicates that VATS lobectomy is technically accomplishable, but subsequent analysis of cancer recurrence rate and survival data is forthcoming. The VATS approach has not yet been proved superior to standard thoracotomy for lung cancer resection.

In a subsequent prospective, randomized trial, 72 involving 61 patients with presumed clinical stage I non-small cell lung cancer, VATS lobectomy was directly compared with muscle-sparing thoracotomy with lobectomy. Six patients were excluded because of nonmalignant disease (three) or because an attempted VATS lobectomy was converted to thoracotomy (three). There were no significant differences in the operating time, intraoperative blood loss, duration of chest tube drainage, length of hospital stay, or disabling postsurgical pain. More complications occurred in the thoracotomy group. Insufficient time has elapsed to report on the long-term local control and survival in each group. This study underscores the importance of not supplanting accepted open procedures with a VATS operation because of purported advantages and limited evidence of equivalence.

Other Operative Applications

Thoracoscopic esophagomyotomy is a new approach for treating achalasia. Thoracotomy or laparotomy can necessitate significant hospital stays.[4] Medical management by esophageal dilation is occasionally complicated by perforation. Peuegrini et al[4] successfully completed 17 of 19 (89%) cases for achalasia by either a VATS (15) or a laparoscopic (2) Heller myotomy. Two (11%) cases necessitated open procedures. The mean hospital stay was 3 days, the mean lower esophageal pressure was lowered from 32 to 10 mm Hg postoperatively, and no deaths or major complications were reported. In the successful cases, short-term results with regard to dysphagia were excellent or good in 14 (82%), fair in 2 (12%) and poor in 1 (6%). Three (21%) of the 14 patients with initial excellent or good results required a second procedure. Long-term outcome data are not reported.

Pericardial effusions, malignant or benign, can be addressed by the less invasive thoracoscopic pericardiectomy. Under single-lung ventilation using a double-lumen endotracheal tube, thoracic surgeons can obtain an excellent view of the mediastinum. To relieve tamponade, a pericardial window of suitable size is cut. Pericardial fluid is then aspirated from the thorax and an intercostal drain is left for further decompression.[5,64] Hazelrigg et al[65] used VATS to perform pericardiectomy in 35 patients after failed medical management and pericardiocentesis. There were no intraoperative and only four postoperative complications (two dysrhythmias, two pneumonias). Although palliative to terminal patients, thoracoscopy may decrease the number of thoracotomies and limit hospitalizations for malignant pericardial disease.[65,66] Its superiority to the subxiphoid pericardial window for both benign and malignant pericardial disease, however, has not been shown.[76]

Mediastinal Tumors

A thoracoscopic approach has been advocated for patients with posterior and middle mediastinal tumors. Access can be difficult, however, and it may be necessary to convert to open thoracotomy in (is greater than) 10% of instances.[29] Postoperative hospitalization is often less than after thoracotomy, but conversion should not be delayed if there is bleeding, the lesion cannot be appropriately exposed, or tumors are large.

Vasospastic Disease

Thoracoscopic sympathectomies are performed using either electrocautery, dissection, or excision in patients with Raynaud's syndrome, causalgia or essential hyperhydrosis.[30] Exposure is usually through the anterior chest wall, and procedures can be performed bilaterally at a single setting.[31]

Bullectomy and Lung Volume Reduction Surgery

Thoracoscopy is an accepted modality for lung volume reduction surgery, with results that appear similar to those obtained after median sternotomy.[34] Endoscopic stapling can be performed with or without buttressing staple lines. Results of bilateral procedures appear better than unilateral procedures, and costs are often less than with median sternotomy.[35] Although improvements in pulmonary function, exercise performance, and quality of life have been noted,[36] FEV_1 often deteriorates toward baseline prelung resection values within 2 years. The role of thoracoscopy *vs* median sternotomy for bilateral lung volume reduction surgery is currently being evaluated in various trials.

Chest Trauma

Thoracoscopy provides an effective and safe modality by which to initially evaluate and often manage stable patients with blunt or penetrating chest trauma.[37] Diaphragmatic injury, hemothorax, and lung parenchymal lacerations can be treated, although difficulties associated with active bleeding, suboptimal single-lung ventilation, or intense pleural inflammation should prompt conversion to an open thoracotomy.

Cardiovascular Disease

Thoracoscopy can be used for ligation of a patient ductus arteriosus,[38] as well as to harvest internal thoracic artery in patients undergoing coronary bypass grafting.[39] A significant reduction in postoperative pain has been described, attributed to the absence of rigorous chest retractions. It is likely that many other applications for thoracoscopy-assisted cardiovascular surgery will emerge.

LIMITATIONS/ COMPLICATIONS AND FUTURE DIRECTIONS

The thoracoscopic approach to a variety of diagnostic and therapeutic problems has few limitations other than a need to demonstrate safety and cost-effectiveness compared with more conventional approaches.

Morbidity

Known complications of thoracoscopy include bleeding, empyema, wound infection, prolonged air leak, tumor seeding at the entry site and death.[7,11-14] It is difficult to summarize the overall complication rate because it depends on the indication, type of anesthesia, equipment, patient population and experience of the operator.

The incidence of subcutaneous emphysema with thoracoscopy ranges from 0.5 to 7%.[28-30] The risk of infection appears to be low, with only 5 (0.5%) infections recorded in a collected series of 1,145 patients.[10] Postoperative fevers were reported in 16% and persistent air leak in only 2% of 817 simple rigid thoracoscopies.[14]

In a retrospective series of 121 diagnostic thoracoscopies performed under general anesthesia, Page et al[9] reported a total complication rate of 9.1% (predominantly respiratory). In a prospective study of 102 diagnostic thoracoscopies performed under local anesthesia, Menzies and Charbonneau[2] reported 5.5% minor and 1.9% major complication rates. Kaiser and Bavaria[68] reported and overall 10% incidence of complications in their series of 266 various thoracoscopies.

Morbidity from thoracoscopic talc poudrage is minimal. Lange et al[69] studied patients 22 to 35 years after tale poudrage for spontaneous pneumothorax and found only a minimal restrictive pulmonary impairment. Fever (16%) and pain (9%) are other minor side effects from talc.[55] Additional complications, such as ARDS or acute pneumonitis (after high-dose intrapleural talc suspension rather than talc insufflation) have been reported, but are extremely rare.[70,71] Caution must be exercised in performing talc poudrage in the young patient, especially in potential lung transplant candidates, because the obliterative pleuritis and resultant fibrosis will complicate future thoracotomy.

Mortality

Boutin et al[72] reviewed 4,300 simple rigid thoracoscopies (mostly diagnostic) and reported a mortality rate of less than 1%. Page et al[9] reported 1 (0.7%) perioperative death among their 121 patients. Ohri et al[10] had 5 of 100 (5%) patients die postoperatively (mean age, 68 years). The VATS study group reported 38 (2.5%) deaths among their various 1,820 interventional cases performed at more than 40 institutions. No patient died intraoperatively in this collected series. Overall, perioperative mortality rates for thoracoscopy range from 0 to 9%.[2,7,1-11,14,73-75,82]

CONTROVERSIES IN THORACOSCOPY

Who should perform thoracoscopy, pulmonologists or thoracic surgeons—is a primary topic of debate. Thoracoscopy can be performed by a pulmonologist under local/regional anesthesia (medical thoracoscopy) or by a thoracic surgeon under general anesthesia (video-assisted thoracic surgery). Techniques of thoracoscopic pleural biopsy, fluid drainage, and pleurodesis are now recognized components of the interventional pulmonologist's practice. Unquestionably, most therapeutic and operative procedures are the domain of the thoracic surgeon. It is imperative, therefore, that the pulmonologist and thoracic surgeon have a close working relationship to ensure proper patient care. At this time, it is unclear which anesthesia technique is best for 'diagnostic' thoracoscopy. Several large series confirm its efficacy and safety under local anesthesia.[2,24,74] Nevertheless, performing thoracoscopy in an operating room with assistance from the anesthesiologist, using single-lung ventilation, and the ability to move quickly to open thoracotomy has distinct advantages. However, the operating room approach is more time-consuming and expensive.

Disagreement exists regarding the appropriateness and timing of thoracoscopy for routine investigation of effusions of unknown origin. Management of patients with suspected malignant effusion varies-recommendations range from observation to progressively invasive procedures culminating in a thoracotomy. Currently, thoracoscopy is employed after several attempts by conventional pleural sampling are nondiagnostic. Thoracoscopy does increase the diagnostic yield for both benign and malignant disease. Preoperative patient characteristics (such as history of malignancy at any time) and clinical data that are predictive of finding malignancy at thoracoscopy have been identified.[15] Knowledge of such features will aid patient selection. The impact of thoracoscopy on the long-term outcome of patients having malignant pleural disease is uncertain. Given the poor prognosis of patients with malignant pleural disease, one can argue that the utility and necessity of diagnosing pleural malignancy by thoracoscopy is questionable until further therapeutic options are developed. VATS wedge resection is being used to treat stage I lung carcinoma.[6] It is essential to safeguard against inadequate resection of non-small cell lung carcinoma because this compromises definitive cure.[5] The local recurrence rate with only 1 cm surgical margins is greater than 20%.[76] The lung cancer study group[77,78] data were recently analyzed to compare the effectiveness of wedge resection with lobectomy in the management of stage I non-small cell carcinoma. Patient survival was equivalent between groups, but local recurrence was 25% greater in the lesser wedge resection group.[77-80] It seems prudent, pending further data, that lobectomy be performed if adequate pulmonary function is present.[5,6,79,81]

VATS lobectomy is technically feasible. There is an insufficient number of controlled studies proving that VATS resection with lymph node sampling provides adequate margins, equivalent recurrence rates, and comparable long-term outcome compared with the time-honored open thoracotomy with lymph node dissection. Further prospective trials are currently underway to directly compare VATS with open lobectomy for stage I non-small cell lung carcinoma. We do not routinely perform VATS lobectomy.

The issue of the expense of thoracoscopic surgery is becoming increasingly important. Although some studies suggest that VATS reduces postoperative pain and hospital stay,[7,8,36] a benefit in terms of health-care savings has not been clearly documented.[8,80,82,83] The disposable instrumentation and the video equipment are expensive. It is clear that attempts should be made to use more reusable equipment. Also, complications or inadequate results that require longer stays, subsequent interventions, or result in shorter survival must be accounted for in the final summation of cost. Finally, measuring direct costs alone may not reflect total benefits. Indirect benefits such as an earlier return to work are difficult to assess.

CONCLUSION

Modern thoracoscopy provides a potentially less invasive means to diagnose and to treat a variety of intrathoracic diseases. Simple rigid thoracoscopy is safe and effective for the diagnosis of benign and malignant pleural disease. It is useful for therapeutic procedures, such as pleurodesis and uncomplicated empyema drainage. Current endoscopic and VATS techniques have the potential to limit morbidity and reduce hospital stays for major operations. This ability, however, provides the potential for its overuse. Thoracoscopy's ultimate acceptance should be based on the results of controlled, randomized trials. Further questions still remain regarding its patient selection, operators, timing, effects on long-term outcome and cost-effectiveness.

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REVIEW ARTICLE

Role of Falloposcopy in the Management of Subfertility

Bello L Zainab

ABSTRACT

Aim: To review the technique and results of falloposcopy and compare it with the conventional methods used in the evaluation of tubal subfertility.

Data source: Electronic library, SpringerLink, PubMed, Google, HighWire, eMedicine and materials from World Laparoscopy Hospital.

Study selection: Studies involving the use of falloposcopy in assessing tubal status were reviewed and compared with conventional methods.

Data synthesis: Falloposcopy gives an excellent assessment of tubal functional status accurately and provides treatment for minor tubal disease and sorts out patients who need IVF for early referral.

Conclusion: There is no doubt, falloposcopy is a gold standard in assessing functional status of the fallopian tube accurately, provides treatment in selected cases and detects patients that needs IVF and refers them in good time but expertize and further training is required to make the procedure routine in the evaluation of subfertility.

Keywords: Falloposcopy, Tubal disease, Classification, Subfertility.

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INTRODUCTION

Infertility is an absolute term so for the purpose of this discussion subfertility will be used. This is defined as inability of a couple to get pregnant despite adequate coital exposure (adequate coital exposure is 2 to 3 times per week) for a period of 1 year. However, this definition varies with age of the woman—for a woman that is 35 years and above, subfertility is regarded as inability to conceive despite adequate coital exposure for a period of 4 to 6 months.[1,2] The prevalence of subfertility ranges between 9 and 35% in the developing countries as compared with 4 to 14% in the developed countries.[2]

Causes of subfertility include:

- Male factors—35%
- Female factors—35%
- Both male and female factors combined—20%
- Unexplained—10%.

Female factors have several categories such as cervical, uterine, ovarian and tubal factors for which this article will be emphasizing in a moment. Fallopian tube is lined with epithelial cells which aid in oocyte transport to the fimbria end. Fallopian tube alone accounts for more than 30% of female subfertility.[3,4] In the evaluation of tubal infertility; the aim should be to ascertain the functional status of the tube not just the patency which more often than not is the case because the tube may be patent but not functional due to damaged cilia and mucosa.[5] Conventional methods such as hysterosalpingograph or laparoscopic chromotubation provide only an indirect assessment of the tubal patency without the status of the tubal mucosa.[5] Salpingoscopy visualizes only the fimbrial end, the intramural and isthmic part are not reached, this is very vital as the pathology could be in that region. False-negative results are common since, tubes that appear normal and patent by hysterosalpingograph could have nonobstructive lesions, such as abnormal endotubal vasculature or epithelial atrophy.[5,6] Falloposcopy can be used as both diagnostic and therapeutic in the management of tubal infertility.

FALLOPOSCOPY

This is sometimes called falloscopy; it is the visual examination of the inside of the fallopian tubes. This procedure involves inserting a tiny flexible catheter through the cervical canal and uterine cavity into the fallopian tube, 0.5 mm flexible fiberoptic endoscope is threaded through the catheter into the fallopian tube. The inside of the tube can then be thoroughly examined on a television monitor via a camera attached to the outer end of the falloposcope.

INSTRUMENT

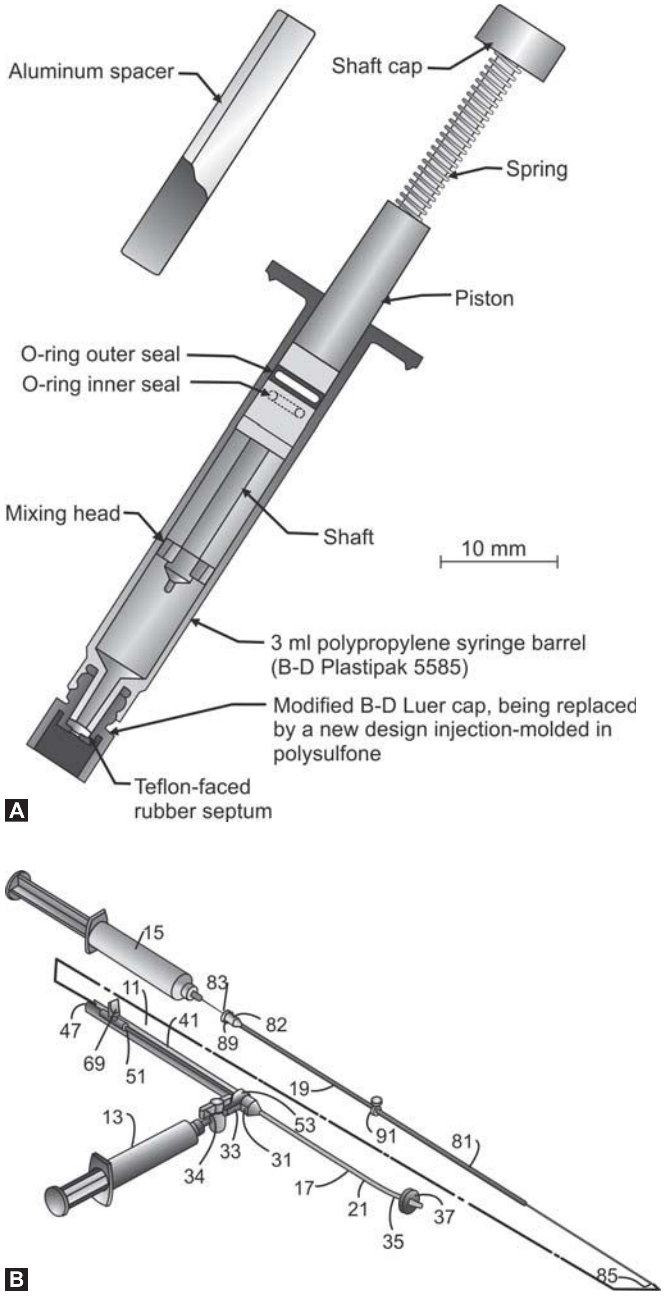
The falloposcope is a flexible high resolution microendoscope of 0.5 mm diameter and 1.73 mm length that contains a bundle of 2000 optical fibers and 8 to 12 illuminating fibers. It is capable of magnifying an object up to 50 times of its actual size.

There are two types of falloposcopes—coaxial system which was manufactured by Kerin in 1970 and linear everting catheter (LEC) (Figs 1A and B), this consists as of unfurling balloon catheter with an internal endoscope that is used transcervically without a hysteroscope, this confers an advantage of coaxial catheter (Figs 2A and B).

PROCEDURE

Falloposcopy is done during the midfollicular phase of the menstrual cycle (from 5-9 days) after menstruation, so that the tubal ostium can be visualized in the absence of blood and thick endometrium. However, prior to the procedure an informed consent is taken from the patient. The process takes 30 to 40 minutes, but if a minor tubal surgery will be performed it takes an average of 1 to 2 and half hours. It is usually done under conscious sedation but if one is proceeding to tubal surgery then it is converted to general anesthesia. A prophylactic antibiotic is not a prerequisite to the procedure.

The LEC consists of inner and outer catheter bodies of diameters 0.8 and 2.8 mm respectively that are joined circumferentially at their distal tips by a distensible polyethylene membrane. The pressure within the enclosed space (the balloon space) is controlled by a fluid-filled syringe. The falloposcopy is advanced within the inner catheter and the membrane is introduced into the uterus. Once the ostium is identified, the outer catheter is held in position and pressure is applied to the membrane by using the fluid-filled syringe; the inner catheter is pushed forward, resulting in the linear eversion of the balloon into the fallopian tube.



Figs 1A and B: (A) Coaxial catheter with preformed soft obturator tip, (B) linear everting catheter

The balloon and falloposcope are advanced into the fallopian tube in small increments, up to a distance of 10 cm or until resistance is encountered. Imaging of the endotubal surface is then performed in a retrograde manner using the lens-fluid interface.[10,12] The LEC system confers a few advantages over the coaxial system.

First, the eversion balloon is unrolled into the fallopian tube without exerting any shearing force between the balloon and the tubal epithelium. The everting balloon will seek the path of least resistance and negotiate any tubal tortuosity. This process greatly minimizes the risk of tubal injury, which is associated with guidewire cannulation in the coaxial system. Second, the falloposcope advances automatically during balloon eversion and can be moved independently to optimize visualization.

Third, there is no need for any hysteroscopy or cervical dilatation, and falloposcopy using the LEC system can be accomplished as an outpatient procedure that requires only local anesthesia.

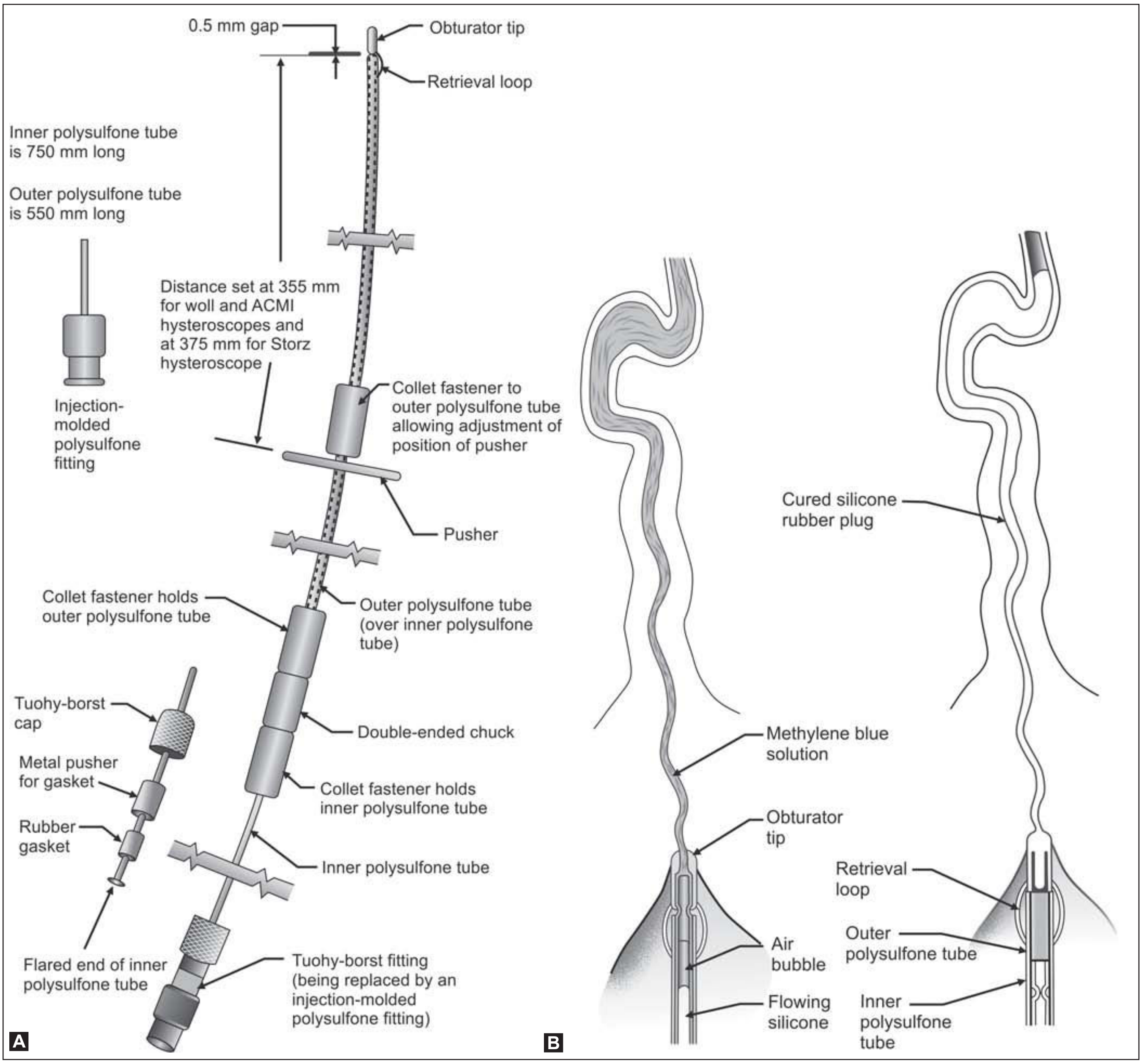
Finally, the falloposcope is well-protected inside the balloon and is kept coaxially aligned along the tubal lumen.

RESULTS FROM FALLOPOSCOPY

Various studies revealed that falloposcopy has being performed in patients with hysterosalpingographic or laparascopic evidence of tubal disease (Table 1). The success rate of cannulation by falloposcopy in abnormal tubes is more than 90%[7] in the majority of recent studies. There is usually a poor correlation between hysterosalpingographic studies and falloposcopy since falloposcopy gives a more accurate visual status of the tube and with HSG false positives could be as high as 40%.[8-10] Eight infertility patients with proximal tubal block by hysterosalpingograph had falloposcopy and patency was established in 9 out of 12 tubes, falloposcopy revealed five tubes with multiple or extensive intratubal lesions that would be unsuitable for unilocular tubal resection with subsequent reanastomosis and recanalization for which five tubes had only minor pathologies, two of which became pregnant and only 2% of the tubes needed tubal surgery. Another randomized controlled study revealed that there is a significant benefit in pregnancy rate when tubes were flushed with oil soluble media and this was supported by falloposcopic procedures.[10-13]

Schille et al revealed in his studies that proximal tubal blockage which is a major cause of subfertility in women could be easily managed with falloposcopy and this yielded good pregnancy outcome.[14] Further studies revealed the importance of falloposcopy in performing tubal cannulation under laparoscopic guidance with both the coaxial and LEC falloposcopes and they achieved 80% success rate.[15] Technical difficulties existed with coaxial falloposcopes more than with LEC during the procedure and this could be attributed to ostial spasm secondary to attempted guidewire cannulation and inability to negotiate the whole tubal lumen in the absence of obstructive disease. These obstacles could be overcome by using smaller directional guidewire, softer distension-free Teflon catheters, improved microendoscopes and improved surgical skills necessary for a safe and fruitful falloposcopy.[16-20] All these studies are revealing the importance and efficacy of falloposcopy in both diagnosing tubal infertility and treating it based on the pathology.

However, falloposcopy has been shown to be a highly useful, minimally invasive procedure in diagnosing and treating patients with proximal, mid and distal tubal disease as a cause of their subfertility. It has also being shown from the aforementioned studies to have a good predictive value for investigation and future fertility.[21]



Figs 2A and B: (A) When methylene blue and silicone (Advanced Medical Grade Silicones BV, The Netherlands) are injected into the fallopian tube, the obturator tip is held in place by the outer catheter, (B) when the silicone has hardened the inner part of the coaxial catheter is then withdrawn and breaks the silicone column (which has extended from the syringe to the ampullary part of the plug) at the junction of the preformed obturator tip (Siegler AM and Lindeman HJ)

Table 1: Various studies showing various falloposcopic techniques and treatment—women health 2010

Study	Technique	Patients no.	Indication	Recannulation success rate (%)	Preg rate	Follow-up (months)	Ref
Schille et al	Falloposcopy and tubal dilatation under laparoscopic control	42	Unilat/bilat proximal tubal obstruction	61.9	12	3-6	14
Rimbach et al	Falloposcopic catheterization	38		80			15
Surrey et al	Coaxial falloposcopy	16	Proximal tubal obstruction	85			15
Rimbach et al	Falloposcopic hysteroscopic laparoscopic coaxial tubal cannulation	367		69.6			16
Pennehouat et al	Falloposcopic hysteroscopic coaxial tubal cannulation	66	Proximal tubal obstruction	83			17
Kerin et al	Falloposcopic hysteroscopic laparoscopic guidewire annulation and tuboplasty	35	Proximal tubal obstruction	81.4			18
Sueok et al	Falloposcopy with linear everting catheter	50	Proximal, mid and distal tubal obstruction	79.4	22	2-36	19
Dechaud et al	Falloposcopy with a linear everting catheter	75	Tubal and unexplained infertility	94.5	27.6		20
Lee	Falloposcopy with linear everting catheter and laparoscopy	20	Tubal occlusion	93			21

Complications of Falloposcopy

These are rare but when they occur, they are usually minor and can be easily managed. Such complications include bleeding, infection, tubal perforation and technical failures on the instrument side and of course lack of clinical expertise could lead to avoidable complications.

Contraindication to Falloposcopy

- Acute or chronic cervicitis or vaginal infection rule out *Chlamydia* and *N. gonorrhea*
- Recent tubal surgery or congenital malformation of the genital tract
- Recent history of PID
- Known or suspected case of genital malignancy.

FALLOPOSCOPIC DIAGNOSIS AND CLASSIFICATION OF TUBAL DISEASE

Falloposcopy provides the opportunity to visualize the lumen of the fallopian tube *in vivo* for proper assessment and evaluation of its functional status.[22] It has been used to classify normal and abnormal epithelial lesions, such as accumulated debris, nonobstructive intraluminal adhesions, stenosis, polyps, total fibrotic obstruction and also segmental identification of location of tubal pathology with minimal or no complication.[23]

In other to effect adequate management of the tubal disease, hence the need for its classification, Kerin et al used a scoring[24] system to classify tubal pathology:

- Falloposcopically normal tubes—46%
- Mild-to-moderate tubal disease—29%
- Severe to obstructive tubal disease—25%.

Studies revealed endotubal lesions in 57% of cases and 70% were confined to the medial third of the tube between the uterotubal junction and ampullary isthmic junction.[24]

Kerin et al further classified tubal disease falloposcopically: Intramural stenosis—five cases, isthmic stenosis—10 cases, isthmic obstructive lesion—five cases, salpingitis isthmic nodosa—two cases, nonobstructive lesion which ranged from intraluminal adhesions, associated devascularization and epithelial atrophy in the intramural, isthmic and ampullary segments—10 cases, hydrosalpinx—two cases and intratubal polyp—one case. In 35 out of 43 falloposcopies performed 18.6% had normal appearance of the fimbrial, ampullary, isthmic and intramural tubal epithelium.[25]

CONCLUSION

Subfertility is a global problem and with the recent sexual debut among the reproductive age group, the incidence of tubal subfertility is on the increase especially in the developing countries; hence, adequate knowledge about falloposcopy will go a long way in alleviating the burden of subfertility with its psychological and emotional burden of the shoulders of the clinician. Falloposcopy no doubt plays a significant role in accurate and precise diagnosis to patients with tubal pathology and providing them with treatment as the case may be and at the same time sorting out the patient that will benefit from IVF on account of severe tubal disease in good time.

FUTURE CHALLENGES

Despite the diagnostic superiority of falloposcopy over the conventional methods in the evaluation and treatment of endotubal disease. There are technical shortcomings like 'white-out' due to intense light in close proximity of tissues, kinking leading to catheter damage and obstruction to successful falloposcopic cannulation and lack of personal expertise required in the technique, limits the routine use of this procedure in our day to day clinical practice.

Hence, the need for a robotically-assisted hysteroscopic falloposcopic fluoroscopic fallopian tube recanalization technique under ultrasound-guided cannulation would help guide the catheter path avoiding tubal perforation during guide-wire cannulation.

The micromanipulation should be simulated on a monitor akin to that used in intracytoplasmic sperm injection.

Use of thermally controlled catheters or guidewires may present the possibility of effectively clearing fibrolytic occlusions that might have being missed during cannulation.

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REVIEW ARTICLE

Techniques to Secure Renal Hilum in Laparoscopic Donor Nephrectomy

Santhosh Narayana Kurukkal

ABSTRACT

Laparoscopic donor nephrectomy is the standard of care in donor kidney procurement for renal transplantation. Use of nonabsorbing polymer locking clips for securing the renal artery in this procedure is widely practiced. The US FDA has given instructions contraindicating the use of Hem-o-lok clips in securing renal artery in donor nephrectomy. This article reviews the modalities for securing renal artery in laparoscopic nephrectomy published in the last decade.

Keywords: Laparoscopy, Donor nephrectomy, Renal artery, Hem-o-lok, Clips, Staples.

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INTRODUCTION

Laparoscopic donor nephrectomy is the standard of care for live renal procurement in transplantations. Generally, clips were used to secure renal artery, but at least five deaths from catastrophic postoperative hemorrhage following laparoscopic donor nephrectomy were reported since 2005 attributable to insecure ligation of their renal artery by a locking clip. US FDA issued a safety information on 5/6/2011 that Hem-o-lok clips are contraindicated in ligating renal artery in laparoscopic donor nephrectomy.[1] The alternatives are suture ligature, oversewing or stapling. Techniques that use transfixion are difficult to perform, time-consuming and challenging. This article reviews the modalities used to secure renal hilum in laparoscopic nephrectomy.

MATERIALS AND METHODS

An extensive electronic search of the medical literature published in the last decade using the keywords laparoscopy, hand-assisted laparoscopic donor nephrectomy (HALDN), Hem-o-lok clips, staples for renal artery. Included the articles mentioning securing of renal artery in laparoscopic nephrectomy for other indications. Excluded articles on the mass ligation of renal pedicle.

RESULTS

FDA issues safety alert to healthcare providers that Weck Hem-o-lok ligating clips should not be used for the ligation of the renal artery during a laparoscopic living-donor nephrectomy because of serious risks to the donor.[1] The clips may become dislodged, which can lead to uncontrolled bleeding, additional surgery or death of the donor. In 2006, the manufacturer added this contraindication to the 'Instructions for Use' after receiving 15 reports of 12 injuries and three deaths which occurred between 2001 and 2005. Since, the contraindication issued in 2006, there have been three more kidney donor deaths, all associated with the contraindicated use.

I searched online in the FDA MAUDE database (Manufacturer And User Facility Device Experience) from 1/1/2001 to 6/30/2011, found two cases of death following use of Hem-o-lok clips in donor nephrectomy.[2] One of the patient undergone laparoscopic donor nephrectomy in 2008 and died on the following day. The incident was reported as approximately 8 hours postoperative, a male donor nephrectomy developed difficulty in breathing and became unresponsive. He was returned to surgery where an exploratory laparotomy was performed and intraperitoneal bleeding was encountered and evacuated from the abdominal cavity. It was noted the clip that had been placed on the renal artery stump during the nephrectomy was not visible. A 1.5 cm tear was noted at the aorta, which was clamped and repaired. The renal artery appeared thin and friable. The patient developed DIC and expired.

The other report stated that a donor died a few hours after a live, donor nephrectomy. The event occurred at the national university hospital. No details were available. The manufacturer (Weck, Teleflex Medical Research Triangle Park NC) examined the batch of Hem-o-lok clips and reported: Pulsatile pump testing was performed which simulates the environment, the clips are subjected to during surgery with respect to closure. The blood pressure that the clips are subjected to is approximately twice the normal blood pressure in humans. The clips were tested for 24 hours and had an acceptance criteria of no clip slippage off the vessels and no failure to the locking mechanism of the clips. At the end of the 24 hours period, no solution was observed from the distal end of the clips. The results of the pulsatile pump testing show the product performed satisfactory. Based on review of the information provided and testing of like product, the device could have been functioning as intended, and we cannot conclude that the reported incident was caused by a failure of the Hem-o-lock clip.

There were concerns about the safety of the nonabsorbable polymer locking clips since 2004 to 2006 and FDA had temporarily banned it in 2006. With reintroduction late in 2006, transplant surgeons, urologists and minimally invasive surgeons were using the polymer locking clips extensively for securing the renal artery in donor nephrectomies as it was clear that the reported clip malfunctions were not frequent. Even though it is infrequent, it is catastrophic and we should respect the privilege of kidney donor.

Intraopeartive clip malfunction is not infrequent. Maartense S et al reported two cases of perioperative clip dislocation during laparoscopic donor nephrectomy and the techniques to tackle the situation.[3] In the first case, during left HLDN the clips placed on the renal artery dislodged, and the surgeon managed to control the bleeding by compressing the focus of the bleeding with his finger. A balloon occlusion catheter was inserted through a groin incision in the aorta and advanced to the origin of the renal artery. Due to control of the hemorrhage, it was possible to close the renal artery stump by laparoscopic suturing and a conversion was averted. In the second case, during right HLDN, the clips on the renal artery dislodged during stapling of the renal vein. The bleeding was controlled by finger compression and new clips were placed. The cuff of the artery was long enough to be clipped again. The use of a balloon occlusion catheter is an elegant way to avert conversion.

Elliott SP et al[4] from the University of California studied the bursting strength with various methods of renal artery ligation and potential mechanisms of failure. One end of an adult porcine artery (3-7 mm diameter) was occluded with a titanium clip, self-locking polymer clip or laparoscopic linear cutting stapler. Comparisons were made with one or two clips and with different distal cuff lengths (i. e. flush or 2 mm). The open end was secured to a pulsatile infusion pump. Leak/failure pressures were measured using a digital barometer. The mean bursting pressures for the clips were found above physiologic arterial pressures (1220-1500 mm Hg). However, the vessels closed with the stapler leaked at a lower mean pressure (262 mm Hg). Failure of titanium or self-locking polymer clips was the result of vessel retraction into and behind the clip, while staple-line leakage occurred between individual staples. Bursting pressures with the titanium and self-locking polymer clips were unaffected by the number of clips or length of vascular cuff. He concluded that all tested methods of vascular control performed well at physiologic pressures, suggesting that safety is not increased with traditional maneuvers such as additional clips or longer cuff length.

The efficacy of nonabsorbable polymer ligating (NPL) and titanium clips applied with and without a 1 mm vascular cuff at physiologic and supraphysiologic pressures *in vitro* equine-vessel model was compared by Jellison FC et al[5] in Loma Linda University Medical Center, CA. Ten millimeter NPL and standard Ti clips were applied to veins (10 mm) and arteries (10, 6 and 5 mm) with and without a 1 mm cuff and tested until they held a pressure of 300 mm Hg (veins) or 760 mm Hg (arteries) for 2 minutes or leaked. The NPL clip was noted statistically more secure on 10 mm veins with and without a cuff, 10 mm arteries with and without a cuff and 6 mm arteries with a cuff than was the Ti clip. Leaving a 1 mm cuff resulted in a statistically higher leak point in all vessels tested except the 6 mm arteries secured with the Ti clip. They concluded that the NPL clip was more secure than the Ti clip on larger arteries and veins. A 1 mm vascular cuff enhances the security of both NPL and Ti clips in vessels of all sizes. The NPL clip is secure and reliable in securing both arteries and veins.

Endolinear stapling devices with clips in hand-assisted laparoscopic donor nephrectomy were compared by Baldwin DD et al.[6] The stapling devices have a potential for misfire. Use of the NPL clip during laparoscopic donor nephrectomy provides increased graft vessel length compared with the stapling device, and the NPL clip has a locking mechanism which may increase security compared with standard titanium clips. The 50 consecutive HALDN patients in their series were conducted with two parallel NPL clips used to control both the renal artery and vein. They opined that the NPL clip was 100% safe and effective in controlling the renal artery and vein during HALDN, allowed for additional vessel length, and resulted in a disposable cost savings of US 362 dollars per patient.

Another report comparing the outcomes in left renal artery clipping *vs* stapling in HALDN by James et al[15] at the Medical College of Georgia. A 55 HALDN procedures were performed by one laparoscopy-trained urologist from 2003 to 2007. During the first 30 months, 27 consecutive HALDN patients underwent renal artery occlusion with two nonabsorbable polymer locking clips (group 1). The subsequent 18 months saw 28 consecutive HALDN patients receive three-row vascular stapling to occlude the renal artery (group 2). The preoperative patient factors were age, sex, body mass index, serum creatinine (Cr) and presence of supernumerary left renal artery. Intraoperative factors included estimated blood loss (EBL), operative time (OT) and warm ischemia time (WIT). Postoperative data were 24 hours Cr and hemoglobin concentration, transfusion requirement, hospitalization time and complications. Data are presented as mean ± standard deviation and analyzed using parametric tests ($\alpha = 0.05$). They found no significant difference between groups with respect to preoperative factors, OT and EBL; however, WIT was shorter in group 2 (3.6 ± 0.2 *vs* 2.6 ± 0.3, $p = 0.048$). Within-group comparisons revealed longer WIT for patients with supernumerary renal artery compared with those with a single artery (group 1, $p = 0.044$; group 2, $p = 0.042$). Moreover, no major between-group variations were seen in postoperative donor outcomes. Left renal artery ligation during HALDN using a three-row vascular stapler is safe and yields donor outcomes comparable with dual polymer clips. In addition, left renal artery stapling may decrease WIT compared with dual clipping.

Casale P et al[7] reported their personal experience in 31 laparoscpic nephrectomies in which both the renal artery and the renal vein were secured using only NPL clips. No renal vessel injuries, cases of clip dislodgement or slippage, or bleeding were recorded. They also achieved meaningful reduction in the cost of procedure.

Lee Ponsky et al[8] reported a multiinstitutional review from nine institutions with laparoscopic trained urologists performed 1695 laparoscopic nephrectomies (radical nephrectomy, N = 899; simple nephrectomy, N = 112; nephroureterectomy, N = 198; donor nephrectomy, N = 486). Follow-up was a minimum of 6 months from the time of surgery. For each case, we used Hem-o-lock clips to control the renal artery. The renal vein was controlled with Hem-o-lok clips in 68 cases (radical nephrectomy, N = 54; simple nephrectomy, N = 3; nephroureterectomy, N = 5; donor nephrectomy, N = 6). Number of clips placed on the patient side of the renal artery was most often 2, occasionally 3. Number of clips placed on the patient side of the renal vein was most often 2 and rarely 3. All cases used the large (L-purple) clip on the artery, and most cases of renal vein used the extra-large (XL- gold) clip on the vein. No cases of clip failure such as intraoperative or postoperative clip dislodgement necessitating reoperation was recorded.

Izaki et al[9] reported 40 laparoscopic nephrectomies in which renal pedicle ligation was accomplished using extralarge (XL) Hem-o-lok clips on both the renal arteries and veins by placing two clips on the patient side and one clip on the specimen side. Vascular control using XL Hem-o-lok clips was successful in all 40 cases, without any slipping of clips or uncontrolled bleeding.

Yip SK et al[10] reported 46 nephrectomies (40 HALDN, 6 lap). Venous control was achieved solely by the Hem-o-lok clips where at least two clips were applied on the patient side. Arterial control was obtained by the Hem-o-lok clips either alone or in combination with the metal clips. Hem-o-lok was successful in all 46 cases without any slipping of clips or uncontrolled bleeding.

Controlled ligation and division of renal vessels is a critical step during any nephrectomy procedure. It has generally been presumed that titanium clip ligation of renal vessels is risky and insecure. In a report from Sir JJ Hospital and Grant Medical College, Mumbai, India,[11] they analyzed their experiences over 5 years with ligaclips 10 mm titanium clips for secure ligation of renal hilum during laparoscopic nephrectomy. Titanium clips of 10 mm were used to secure renal vessels in 86 patients. They managed to get across the entire width of renal vein with a 10 mm titanium clip by crimpling the vein with the help of the clip applicator before firing the clips. In all except two cases, ligaclips alone were enough to ensure secure occlusion of renal hilum. There was no incidence of slippage or dislodgement of clips applied on renal vessels. On cost analysis, it was found that the Hem-o-lok clip and gastrointestinal anastomosis stapling device were approximately 6-fold and 12-fold costlier than ligaclips.

Another report from Sanjay Gandhi Postgraduate Institute of Medical Sciences, Lucknow, India, (Kapoor R et al)[12] included 246 laparoscopic ablative nephrectomies (178 simple; 68 radical) were performed for benign and malignant conditions, underwent either standard transperitoneal (N = 204) or retroperitoneal (N = 42) nephrectomy. Venous and arterial control was obtained using Hem-o-lock clips. In cases where the clips could not be applied directly on the renal vein, various maneuvers were employed to secure the occlusion. The features compared were the number of clips used, safety, cost and requirement for blood transfusion. Conversion to an open procedure was required in 36 patients (28 in the transperitoneal group and 8 in the retroperitoneal group). In all cases, arterial and venous control was achieved by application of two Hem-o-lok clips on the patient side. Blood transfusion was required by 7.2% of the patients (right-side nephrectomy 4.6%; left-side nephrectomy 2.6%), but none was attributable to clip-related complication.

Ryan SA Hsi et al[13] reported a review to characterize the mechanisms of failure and patient outcomes during complications with the use of endoscopic stapling devices, nonlocking titanium clips, and locking polymer clips during laparoscopic donor nephrectomy. They identified 92 cases of complications due to device malfunctions. In the 92 complications identified, 59 (64%), 21 (23%), and 12 (13%) failures of endoscopic staplers, titanium clips and locking clips had occurred respectively. The most common mechanisms of stapler failure were missing/malformed staple lines (51%) and failure to release (25%). The most common titanium clip failures resulted from scissoring or malformation (52%), jamming (19%) and dislodgement (14%). Clip dislodgement was most common with the locking clip, either postoperatively in seven (58%) or intraoperatively in three (25%). Intraoperative conversions were required for 21 (36%), one (5%) and two (17%) for staplers, titanium clips and locking clips respectively. The estimated overall failure rate was 3.0% for staplers, 4.9% for titanium clips and 1.7% for locking clips. They concluded that donor surgeons must be familiar with and anticipate the potential failures seen with each of the techniques used to secure the renal hilum. Knowledge of potential device failures, combined with prompt and appropriate corrective action, may limit donor morbidity when malfunction occurs. Finally, it is the responsibility of surgeons to act as donor advocate and continue to petition device manufacturers to improve the safety of existing devices. In a previous study by the same author of complications with hemostatic devices during laparoscopic nephrectomy, they observed a greater proportion of locking clip failures occurring during donor procedures compared with stapler and titanium clip failures (67 *vs* 24 and 19% respectively).[21]

Nasser Simforoosh et al[14] reported the use of a new modification of the technique for controlling the renal pedicle during laparoscopic donor nephrectomy (LDN) with Hem-o-lok clips. They did LDN in 241 candidates. At the end of procedure for renal-artery closure, one 10 mm Hem-o-lok clip was applied a few millimeters distal to the root from the aorta, and a medium-large titanium clip was applied distal to the Hem-o-lok clip using a nonautomatic firing applier to exert sufficient closing pressure to the titanium clip to ensure adequate tightness. Then the renal vein was doubly ligated with one 12 mm and one 10 mm Hem-o-lok clips. They reported that there were no intraoperative or perioperative bleeding complications, clip dislodgments or slippages. The conversion rate was zero, and the mean warm ischemia time was 7.50 ± 0.71 minutes (range, 3-17 minutes). Graft function was excellent, with a mean serum creatinine concentration of 1.42 ± 0.46 mg/dl after 12 months of follow-up and no renal-artery or vein thrombosis in any of the grafts. They concluded that with these techniques, there is more security on the arterial closure, and sufficient pedicle length can be obtained for anastomosis. The warm-ischemia time is within an acceptable range. Also, this approach is less expensive than the use of endovascular staplers.

Tmsit et al[16] reported the feasibility of a simple surgical artifice that aims to preserve the advantages of lockable clips with increased safety while respecting the manufacturer's legal recommendations. Since January 2009, a polyglactin-0 tie was placed on the renal artery in addition to the two usual Hem-o-lok clips in LLDN at our institution (n = 10) using a pretied loop suture (Endoloop ligature, Ethicon) placed on the artery stump, proximally to the aorta, after kidney removal. This artifice increased operating time of 65 seconds (range, 35 to 85 seconds) with no modification of warm ischemia time and led to visually decreased aortic pulsation transmitted to the clips. Without evidence of increased safety, they assume that this use may protect surgeons from prosecution in cases of clip displacement. It certainly decreases the risk of clip slippage and should be considered as a cheap, easy artifice to reduce the already low-risk of hemorrhage in LLDN.

Liu et al[17] had concerns about the stapler malfunction and satisfied clips. They had no vascular complications and no device failure during vascular control using polymer locking clips. They believe that polymer locking clips are safe, yielding greater vessel length during laparoscopic donor nephrectomy.

Geron et al[18] from South America described their experience with the use of nonabsorbable polymer ligaclip (NPL) to control the renal artery, vein, and ureter in hand-assisted laparoscopic donor nephrectomy (HALDN). They performed 85 procedures and reported the NPL was safe and cost-effective, not increasing morbidity of the procedure.

Edmund et al[19] reported a retrospective review of Mayo Clinic experience with 400 LDN from 1999 to 2007. The endovascular gastrointestinal anastomosis (GIA) stapler has been used for renal vascular control for their donors since the inception of their LDN program. Forty-one were on the right. There were no statistically significant differences between the donor groups or their respective recipients. There were four (1%) stapler malfunctions, all occurring on the left side; two of these procedures were converted to open to obtain hemostasis. There were nearly equal rates of vascular complications, 4.9 and 4.7%, in the right and left groups respectively. The overall immediate graft failure rate was 2.3%. Right and left recipient creatinine levels up to 24 months demonstrated no statistically significant differences. They proposed that the endovascular GIA stapler for left and right laparoscopic donor nephrectomy is safe for the donor. It standardizes the process, minimizes the need for additional maneuvers in securing the renal hilum, and produces similar outcomes for the recipient. The transplant team also plays an equally large role in favorable graft outcomes.

In contrast to vessel wall occlusion with metal clips, the Endo-TA stapler transfixes the vessel with three rows of staples and has been shown to preserve vessel length compared with the Endo-GIA and Endopath devices.[20]

DISCUSSION

Laparoscopic donor nephrectomy is the preferred mode of renal procurement and it demands more surgical skill compared to conventional laparoscopic nephrectomy. The need for adequate length of renal artery on the left side force to reduce the renal artery stump. The need for securing gonadal, adrenal and lumbar veins make the situation difficult. The shorter right renal vein poses risk on the right-sided nephrectomy. Moreover, the surgeon is in a hurry during the clue time to reduce the warm ischemia time.

Nonlocking clips, locking polymer clips and staples and ligatures were used, all with safety, but none is 100% safe. Stapling devices poses potential for missing, malformed staple lines, and failure to release. In renal arteries with early branching, surgeons feel it challenging to get multiple renal arteries with graft rather than to get the proximal end with single stem. Stapler and NPL are costlier 12 and 6 times respectively when compared with titanium clips. NPL clips increase the graft length, locking mechanism increases security. Chances of dislocation are more with intraoperative conversion and postoperative exploration. Titanium clips poses the risks of scissoring, malformation, jamming and dislodgement.

Surgeon should be familiar to all the potential problems that arises with securing of the renal artery and should anticipate the device malfunctions. Reminding some of the precautions already known to all may be of use. Take precaution in all steps of vessel dissection, the vessel should be nicely dissected off all fatty tissue before applying the device. When using clips, a minimum number of two clips should be applied on the donor side, with adequate gap between them to form a perfect dumbbell. Apply the clip at right angles to the vessel. Obliquely applied clips are insecure. Clearly visualize all around the clip. There should be adequate vascular cuff beyond the clip (1-2 mm). Avoid electrocoagulation in the vicinity of clips to prevent conductive tissue necrosis and subsequent clip dislocation. When using NPL clips, other augmenting modalities like the use of pretied loop suture, and use of a titanium clip distal to the NPL clip can also be considered. Use of suture ligature with inracorporeal or extracorporeal knotting is always safe there in the hands of a laparoscopic surgeon.

CONCLUSION

The various securing devices for renal artery in laparoscopic donor nephrectomy are generally safe, but not exempt from infrequent malfunctions and complications which can be lethal and cannot be neglected. As the live kidney donation is a gift of life, it is our responsibility to ensure the donor safety.

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REVIEW ARTICLE

Prevention of Common Bile Duct Injuries in Laparoscopic Cholecystectomy

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ABSTRACT

Despite advancement in training and technology since its introduction, more than 20 years ago, bile duct injuries continue to be two to three times more common than in open surgery causing significant morbidity and mortality. Hence, a review of the literature present on the internet on bile duct injuries in laparoscopic cholecystectomy was performed to review the causes of biliary injury and methods of prevention of such mishaps. There was a general consensus that careful dissection and correct interpretation of the anatomy avoids the complication of bile duct injury during cholecystectomy. Routine intraoperative cholangiography is associated with a lower incidence and early recognition of bile duct injury. A low threshold to conversion to open approach in case of uncertainty was also advocated.

Keywords: CBD injury, Complication of laparoscopic cholecystectomy, Common bile duct injury.

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INTRODUCTION

Since its introduction by Erich Muhe in 1985, laparoscopic cholecystectomy has gained worldwide acceptance within a short period of time to become the gold standard treatment for cholelithiasis.[1] However, along with all the advantages subsequent upon a minimal invasive procedure, came the inherent drawbacks of performing surgery in a new and unfamiliar way. The incidence of bile duct injuries were definitely increased compared with the open technique.[2] Subsequent improvements in the equipment and refinement in technique, as well as improved training in the laparoscopy, resulted in a progressive decrease of the incidence of these injuries. Nevertheless, global incidence of CBD injury has remained fairly constant around 0.5%, as reported by various meta-analyses studies over a 15-year period.[3] In the United States, 34 to 49% of surgeons have caused a major bile duct injury with an individual experience of one to two such cases.[4] Increasing evidence suggests that such injury should be managed by an experienced hepatobiliary surgeon and that early recognition of injury directly affects outcome. Furthermore, it continues to be two to three times more common compared with published major bile duct injury rates for open cholecystectomy which indicates that this is still an incompletely resolved problem.[5,6]

The problem is especially highlighted as patients sustaining a bile duct injury (BDI) during cholecystectomy have an impaired quality of life. Bile duct injuries often necessitate several invasive procedures and subsequent operations causing fear and anxiety to patients as well as surgeons. Studies show that such patients continue to have a higher risk of dying as compared with those who have an uncomplicated cholecystectomy.[7] There is a significant increase in healthcare expenses associated with the complication and this is a common reason for medical malpractice litigation.

AIM

This article aims to review the causes of biliary injury and methods of prevention of such mishaps.

MATERIALS AND METHODS

A literature search was performed using internet with medical search engines Pubmed, Medscape using the keywords—bile duct injuries in laparoscopic cholecystectomy, prevention of bile duct injuries. The articles obtained were then reviewed using the broad categories of risk factors for BDI, classification of BDI and methods of prevention.

DISCUSSION

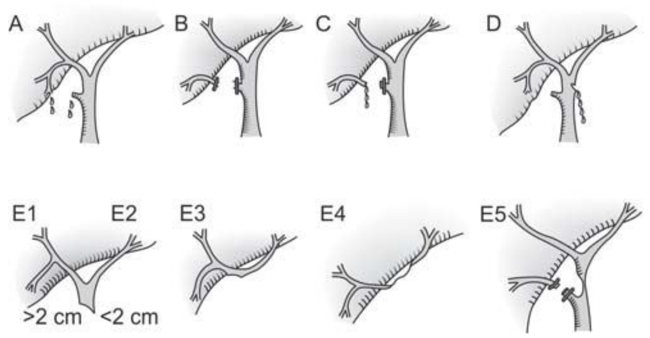
Classification of Bile Duct Injuries

The traditional Bismuth classification was modified in 1995 by Strasberg et al broadening the details to separately identify those injuries seen with increased frequency during laparoscopic cholecystectomy (Figs 1A to E5).[2] This classification, based on anatomic location and severity, is widely used currently.

RISK FACTORS FOR BILE DUCT INJURIES

Training and Experience

Early reports obtained in the 1990s, suggested that the high injury rates were due in part to the inexperience in this new procedure. This was called the 'learning curve effect'.[8] A decrease in the frequency of BDI was therefore expected



Figs 1A to E5: Classification of laparoscopic injuries to the biliary tract[2]

as surgeons progressed beyond the learning curve. However, more than 20 years after the introduction of the procedure, with dramatic advancement in training and technology, there is still no evidence of any remarkable improvement. Hence, other factors besides the inexperience have to be considered. Although most injuries occur within the surgeon's first 100 laparoscopic cholecystectomies, one-third happen after the surgeon has performed more than 200 showing that it is more than inexperience that leads to bile duct injury.[4]

Disease Severity

Severity of the underlying disease process has been proved to be an important risk factor. As in its open counterpart, biliary injuries are more likely to occur during difficult laparoscopic cholecystectomies.[9] Laparoscopic cholecystectomy performed for acute cholecystitis has a three times more likelihood of causing a biliary injury than an elective laparoscopic case, compared with a two-fold increased incidence in open cholecystectomy for acute cholecystitis.[10] Ooi et al reported a retrospective review of 4,445 laparoscopic cholecystectomies with 19 biliary injuries (0.43%). They found that inflammation at Calot's triangle was an important associated factor for injury.[11] Other mentioned risk factors include old age and male gender.

Anomalous Anatomy

As in any biliary surgery, this is a common cause of error, especially in laparoscopic surgery. The aberrant right hepatic duct anomaly is the most common problem leading to an injury. Injury to aberrant right hepatic ducts during laparoscopic cholecystectomy has been reported in various studies.[12] However more often, such injuries are underreported as occlusion of an aberrant duct may remain asymptomatic. Such aberrant ducts seem especially vulnerable during laparoscopic cholecystectomy.[2]

Direct causes of Laparoscopic Biliary Injuries

Misidentification Errors

The most serious injuries are known to be caused by misidentification of anatomy. It has been suggested that the commonest cause of common bile duct injury is misidentification of biliary anatomy (70-80%).[6] There are two main types of misidentification. In the first scenario, the common duct is mistaken for the cystic duct, and is occluded and divided. Subsequently, the bile duct must be divided again later in the dissection during removal of gallbladder, usually reported to as a 'second cystic duct' or 'accessory duct'. An E1 to E4 injury results, depending on the level of the second biliary tree division. Such injuries are often associated with right hepatic arterial injuries which may lead to torrential bleeding followed by conversion or may simply be an unrecognized occlusion of the artery.[13]

A second misidentification injury involves the aberrant right hepatic duct, present in 2% of patients. The segment of the aberrant right hepatic duct lying between its junction with the cystic duct and the point at which it joins the common hepatic is misidentified as the cystic duct. Hence, the surgeon unknowingly clips and cuts out this segment. For removal of the gallbladder, the aberrant duct gets cut again, but at a higher level.

The direction of traction of the gallbladder has been known to contribute to the appearance that the common bile duct is the cystic duct and this can lead to the misidentification injury. When the pouch of Hartmann is pulled superiorly instead of laterally, the cystic and common bile ducts are aligned and appear as a single structure.[14] This deception is more common when the following factors are present—a short cystic duct, a large stone in the pouch of Hartmann and severe, acute and chronic inflammation. Mirizzi's syndrome, in which the gallbladder communicates directly with the common bile duct following recurrent inflammation, is a common cause for error. Misidentification may lead to injury of the bile duct even without division or clipping, because extensive dissection can lead to devascularization of the bile duct which present later as a stricture.

Technical Errors

Failure to occlude the cystic duct securely: Closure of cystic duct is usually done by clips, which remains unreliable if not applied correctly, as opposed to ligatures in open surgery. Clips may 'scissor' during application, resulting in faulty closure or be loosened by subsequent dissection.

Too deep dissection on the liver bed: Injury to ducts in the liver bed is due to dissection in too deep a plane while removing the gallbladder. It often occurs when the dissection is difficult especially or when the gallbladder is intrahepatic.

Thermal injuries: Cautery induced injuries are also more common in the presence of severe inflammation. This is due to the use of excessively high cautery settings to control hemorrhage.

Tenting injuries: In a tenting injury, the junction of the common bile duct and hepatic bile ducts is occluded when a clip is placed at the bottom end of the cystic duct while forcefully pulling up on the gallbladder.

Prevention of Bile Duct Injuries

Bile duct injury should be regarded as preventable, but in a study of surgeons' anonymous response after bile duct injury during cholecystectomy published in the American Journal of Surgery in 2003, over 70% of surgeons regarded it as unavoidable.[15] Following early experiences with such injuries in early 90's, Hunter and Troidl proposed several techniques to prevent injury: A 30º telescope, avoidance of diathermy close to the common hepatic duct, dissection close to the gallbladder—cystic duct junction, avoidance of unnecessary dissection close to the cystic duct—common hepatic duct junction, and conversion to an open approach when uncertain.[16,17] However, to apply these techniques, correct interpretation of the anatomy is required.

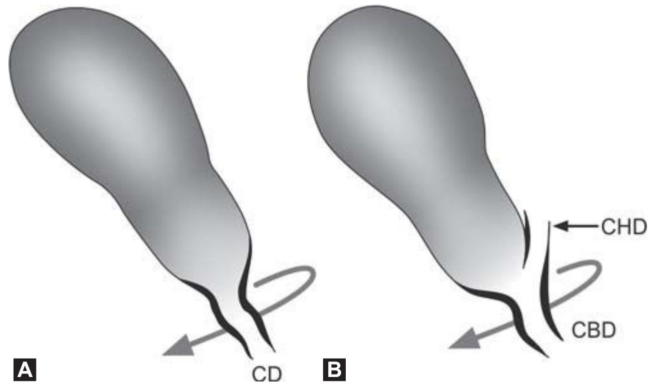
Preventing Misidentification Errors

Misidentification is due to failure to achieve conclusive identification of the cystic structures. The cystic duct and artery are the only structures that require division during cholecystectomy, hence the objective of dissection primarily is to identify these structures conclusively. There are several methods of identification of the cystic duct. In the open method, display of the confluence of the cystic duct with the common hepatic duct to form the common bile duct was used which is considered not safe in the laparoscopic method. In the laparoscopic form of surgery, techniques used are intraoperative cholangiography, the infundibular technique and the critical view technique.

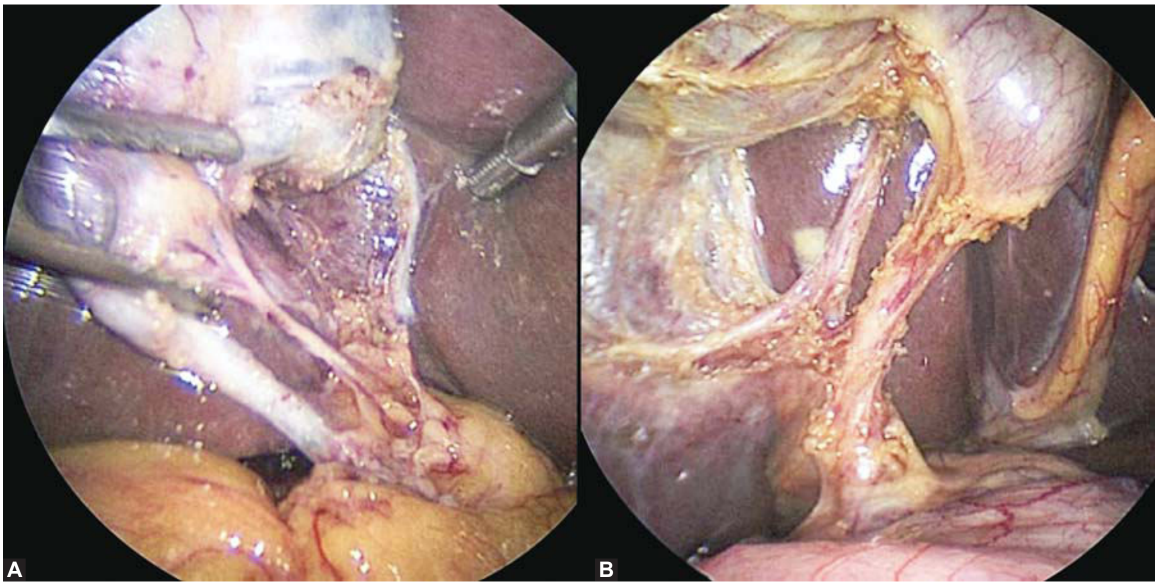
The infundibular technique is a method initially used for ductal identification based on three-dimensional demonstration of the funnel-like shape of the lower end of the gallbladder and adjacent cystic duct. To obtain this view, cystic duct is followed onto the gallbladder or the lower end of the gallbladder is traced down to the cystic duct. When dissection is completed, the funnel-shaped union of cystic duct with gallbladder can be seen in three dimensions. The fallacy of this technique is obtaining a false 'infundibular views' when the CBD is followed up to an inflammatory mass within which the cystic duct is hidden (Figs 2A and B). This visual deception occurs especially in presence of severe acute or chronic inflammation, a large stone in the pouch of Hartmann, adhesive bands between the gallbladder and the common hepatic duct and intrahepatic gallbladder. Chronic inflammation tends to cause retraction of structures in the porta hepatis, bringing the gallbladder against the CHD so that it appears as a part of the gallbladder wall. If this view is relied upon for ductal identification it will, in these cases, result in division of the CBD.[18]

The critical view of safety technique, advocated by Strasberg involves tentative identification of these cystic structures by dissection in the triangle of Calot (Figs 3A and B), followed by dissection of the gallbladder off the liver bed. In this technique, the triangle of Calot is cleared of fat and fibrous tissue and after detachment of the gallbladder; only two structures are connected to the lower end of the gallbladder—the cystic duct and artery. It is not necessary or recommended that the CBD be visualized.[2] Failure to achieve this critical view is an absolute indication for conversion or possibly cholangiography to define ductal anatomy.

Following its introduction, this critical view method has been accepted by many surgeons for its superior results with regards to minimizing BDIs. Averginos et al in 2009 published the result of 1046 cholecystectomies without BDI using the critical view method.[20] Only five patients had transient biliary leaks in the postoperative period which subsided within 2 to 14 days. Similarly, Yegiyants and Collins analyzed the role of critical view of safety in 3,000 patients undergoing elective cholecystectomy and reported one bile duct injury, which occurred during dissection of Calot's triangle, prior to achieving the critical view.[19,21] Sanjay et al in 2010 studied its safety in 447 cholecystectomies done for acute biliary pathologies and reported no BDIs. Critical view was obtained in 388 (87%) patients and



Figs 2A and B: (A) The usual anatomy when the infundibular technique is used, (B) anatomical situation in some cases of classical injuries[21]



Figs 3A and B: (A) Critical view of safety (CVS) is seen from in front of the gallbladder as usually shown, (B) CVS is seen with the gallbladder reflected to the left, so that a posterior view of the triangle of Calot is shown[22]

in the remaining where it was not obtained, conversion to open surgery was done.[22]

Another method of conclusive identification of cystic structures is by routine intraoperative cholangiogram. Several prospective studies have tried to evaluate the usefulness of IOC in preventing CBD injury. A meta-analysis of 40 case series detailing 327,523 LCs and 405 major injuries was performed in 2002.[23] Rate of injury was halved in the routine IOC group (0.21%) as compared with the selective group (0.43%). In addition, in the selective group, only 21.7% of CBD injuries were detected intraoperatively. Fletcher et al found that routine IOC reduced the incidence of injury.[24] The study method adjusted for confounding variables, such as age, sex, hospital type and severity of disease. One argument against cholangiography is, if the CBD is misidentified while an IOC is being performed, the ductotomy created for placement of the IOC catheter is itself a CBD injury. However, other studies suggest that the severity, but not the incidence of biliary injury is reduced by routine IOC. Operative cholangiography is best at detecting misidentification of the common bile duct as the cystic duct and will prevent excisional injuries of bile ducts, if the cholangiogram is correctly interpreted. In an analysis of 252 bile duct injuries during cholecystectomy, Way et al reported that 43 IOCs demonstrated a bile duct injury, but only nine were correctly interpreted at the time of operation.[25]

Recently, other techniques proposed to correctly identify biliary anatomy include the use of dyes. Ishizawa et al reported using fluorescent cholangiography technique using the intravenous injection of indocyanine green.[26] The biliary structure was delineated in all 52 patients studied using the fluorescent imaging system. However, the cost involved is a deterrent for widespread use. Similarly, Sari et al proposed injecting methylene blue in the gallbladder after aspirating the bile with a Varess needle before starting dissection.[27]

To overcome the problem of anatomical orientation, before starting dissection, identification of fixed anatomical landmarks is helpful. Hugh recommends identifying Rouviere’s sulcus as a fixed extrabiliary point ventral to the right portal pedicle.[28] Dissection ventral to this allows a triangle of safe dissection when the gallbladder has been reflected cephalad. Extending this dissection as far as possible up the gallbladder fossa both posteriorly and anteriorly allows the hepatobiliary triangle to open out. This ensures no unexpected anatomy and confirms the correct anatomical position before any significant structure is divided.

In cases of difficulties due to severe adhesion of the gallbladder to surrounding and severe fibrosis, some have advocated using laparoscopic subtotal cholecystectomy as an alternative to conversion as equal difficulty in dissection would be required in the open surgery as well. They claim that conversion does not guarantee the avoidance of inadvertent biliary or vascular injury.[29] Tian et al in 2009, reported performing laparoscopic subtotal cholecystectomy in 48 difficult cases out of 1558 laparoscopic cholecystectomies without any serious bile duct injuries.[30]

Human Factors and Bile Duct Injury

Although thorough instruction in the principles of safe surgical technique for cholecystectomy is essential, it may be equally important to develop new training strategies that use knowledge of psychologic factors in the production of error. This is the human factors approach described by Reason in 'high-reliability organizations', such as air-traffic control and the nuclear power industry.[31] In such environments, highly trained professionals carry out complex technical tasks and are sometimes required to make rapid decisions in conditions of uncertainty with potentially disastrous consequences of mistakes. Some error is inevitable when human beings interact with complex technical environments, as in the operating room. A specific type of error, recognized as the cause of some aircraft crashes, seems to operate in many cases of bile duct injury: The false hypothesis or deadly mind-set error. A mistaken perception, that a particular duct is the cystic duct, provides the setting for this type of error in cholecystectomy. The surgeon may develop a functional fixity and reject evidence of a mistake. The unwillingness of juniors to question the actions of seniors has been identified as a significant contribution to errors in the operating room. The characteristics of a surgeon at low risk for error is often identified as being a person who expects unpleasant surprises; accepts input from others; is ready to modify hypotheses; and recognizes the effects of self-fatigue, time pressures, and personal worries on surgical performance. Hunter suggested that a team approach may be beneficial, stating that the cystic duct should not be clipped until all members of the operating team are contented that the dissection is complete.[16]

CONCLUSION

Bile duct injuries have cast a shadow of apprehension on an otherwise wonderful procedure of laparoscopic cholecystectomy. Millions have benefited from this advance against gallbladder disease. Hence, to preserve these benefits, the operating surgeon has to be aware of the factors responsible for these injuries and take appropriate measures to prevent them. This requires strict adherence to the principles of meticulous dissection so that only positively identified structures are divided. Routine use of intraoperative cholangiograms and converting to open procedure in the event of failure to progress or uncertain anatomy would go a long way in significantly reducing this mishap.

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REVIEW ARTICLE

Robotic Colorectal Surgery

Hossam Eldin Abdel Razik Ibrahim Aldakony

ABSTRACT

Aim: Studies reporting outcomes of robotic colorectal surgery were identified by systematic searches of electronic databases. Outcomes examined included operating time, length of stay, blood loss, complications and cost and conversion rates.

Results: Fifteen studies (nine case series, four comparative studies, two randomized controlled trial) describing 420 procedures were identified and reviewed. Robotic procedures tend to take longer and cost more, but may reduce the length of stay, blood loss and conversion rates. Complication profiles and short-term outcomes are similar to laparoscopic surgery.

Conclusion: Robotic colorectal surgery is a promising field and may provide a powerful additional tool for optimal management of more challenging pathology, including rectal cancer. Current evidence suggests that the safety and feasibility of robotic colorectal surgery has been established. The advantages conferred by the robot are particularly useful for rectal dissection. Although the majority of published studies are case series or nonrandomized comparative studies, data show equivalent clinical short-term outcomes except for longer operating times and lower conversion rates compared with laparoscopic surgery. However, the lack of prospective randomized studies precludes definitive conclusions. Multicenter, prospective randomized controlled trials designed to evaluate safety, feasibility, cost-effectiveness and long-term outcomes will provide crucial information on the practice of robotic colorectal surgery.

Keywords: Robotic surgery, Laparoscopy, Colorectal.

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INTRODUCTION

Over the last 30 years, minimally invasive techniques have revolutionized general surgical practice, above all impacting surgery of the gastrointestinal (GI) tract. Benefits of such an approach have been observed in almost all surgical subspecialties and include reduced postoperative pain, shorter hospital stay and an improved cosmetic outcome.[1] Though slower to gain acceptance, laparoscopic colorectal surgery has gained in popularity, and in experienced hands is now regarded as a safe and feasible alternative to open surgery. Early concerns over oncological outcomes have been addressed by several large randomized studies, demonstrating comparable results between laparoscopic and conventional surgery.[2-5] Nevertheless, the long learning curve, together with inherent difficulties such as two-dimensional imaging, limited dexterity and diminished tactile sense have meant that the application of laparoscopic surgery to technically demanding. Colorectal procedures continue to present a challenge, in particular for restorative resection of mid and low rectal cancers.[6,7] Robotic surgical systems may offer a solution in overcoming these difficulties. A number of systems have been reported and offer several advantages overconventional laparoscopic surgery including; first, it has a magnified full high definition 3D camera that is under the control of the surgeon. Second, the instruments have a free articulating endowrist. The full articulating robot arms facilitate the dissection and retraction of the specimen in these complex surgeries and enhanced dexterity. Third, the movements of the robotic arms are precise with complete elimination of the tremors produced by the surgeon's hand. Fourth, the ergonomic position of the surgeon while working in the console reduces the muscle strain on the surgeon that is seen with conventional laparoscopy.

Although surgical robots have been successfully applied to a number of disciplines, most notably urological and cardiac procedures,[8,9] robotic colorectal surgery remains in its infancy. The first two cases of robotically assisted colectomy were performed in 2001[10] and since then there have been a number of publications on the use of robotic systems in colorectal surgery.

The da Vinci surgical robot has been used for general surgery procedures, and there has been an increase in the last few years in colorectal surgery but there is still no standardized technique (Figs 1A and B). For left colon resection and LA procedures, it has been described in several procedures:

1. *Hybrid technique:* Technique that mainly consists of laparoscopic mobilization of splenic flexure followed by robotic docking for the dissection of the pelvis and completion of the procedure.
2. *Single-docking technique (described by Kim SH):* Technique that incorporates mobilizing the second and third robotic arm for the different parts of the procedure utilizing single docking at the left lower quadrant (splenic flexure mobilization and for the pelvic dissection).
3. *Double-docking technique (described by KY Lee and BS Min):* Technique that incorporates docking from the left hemiabdomen for dissection of the splenic flexure and then changing the docking to the left lower quadrant and placing an extra port at the right hemiabdomen for the pelvic dissection.

AIM

The aim of this review is to provide a comprehensive and critical analysis of the available literatures on the use of robotic technology in colorectal surgery.

METHODS

Google, SpringerLink and HighWire Press search engines had been gone through using the following keywords: robotic colorectal surgery. Fifteen recent (> 2005) articles had been deliberately reviewed. This review will concentrate upon the following main points: Operative time, blood loss conversion rate, hospital stay and complication.

RESULTS AND DISCUSSION

The first robotic-assisted colectomies were reported in 2002 by Weber et al[10] who performed successful robotic-assisted laparoscopic sigmoidectomies and right hemicolectomies for diverticulitis. Since then, wide range of colorectal operations have been performed, including right and left hemicolectomies, sigmoid resections, rectopexies with/without resection, anterior resections, abdominoperineal resections and total colectomies.[10,15,20,23,25-28]

Table 1 shows chronologically how robotic surgery has been applied in the field of colorectal surgery. In the beginning, robotic surgery was performed in a variety of types of operations and embraced a wide range of diseases including both benign and malignant.[26,27] It appears to be a process of verifying the safety and feasibility of this new technology and it was a process for finding where we could achieve maximum benefits from the robotic surgical system. The indications for its use are still evolving and many colorectal surgeons are passionately adopting the robot and trying to discover the boundaries where the robot can be applied. Spiniglio et al[20] reported their initial 50 cases of robotic colorectal surgery, comparing them with 161 conventional laparoscopic cases during the same time periods. The types of operation were evenly distributed from right colectomy to anterior resection and these operations

Figs 1A and B: (A) Operation theater with the da Vinci surgical system, and (B) an operator at the master console

Table 1: Clinical application of robots in colorectal surgery

Reference	*Year*	*Country*	*Study type*	*Number*	*Platform*	*Procedure(s)*
Braumann[11]	2005	Germany	Case series	5	da Vinci	RHC(1) SC(4)
Woeste[12]	2005	Germany	Comparative	6	da Vinci	SC(4) RP(2)
Ruurda[13]	2005	Holland	Case series	23	da Vinci	RP(16) ICR(5) SCS(2)
Sebajang[14]	2006	Canada	Case series	7	da Vinci	RHC(3) SC(3) AR(1)
Pigazzi[15]	2006	USA	Comparative	6	da Vinci	AR(6)
DeNoto[16]	2006	USA	Case series	11	da Vinci	SC(11)
Hellan[17]	2007	USA	Case series	39	da Vinci	AR(33) PRC(6)
Rawlings[18]	2007	USA	Comparative	30	da Vinci	RHC(17) SC(13)
Baik[19]	2008	Korea	Randomized	18	da Vinci	AR(18)
Spinoglio[20]	2008	Italy	Comparative	50	da Vinci	RHC(18), LHC(10), AR(19), APER(1), TRC(1) TC(1)
Fabrizio et al[21]	2009	Italy	Case series	55	da Vinci	LHC(27) AR(17) APR(7) TRS(4)
Kim et al[22]	2010	Korea	Case series	15	da Vinci	RHC(13) SIG(5) PEXY(2) AR(125) APR(9)
Zimmern et al[23]	2010	USA	Case series	131	da Vinci	APR(11) TPRRHC(42) SIG(16) PEXY(8) AR(47)7
Ragupathi et al[24]	2011	USA	Case series	24	da Vinci	AR(24)

RHC: Right hemicolectomy; ICR: Ileocecal resection; TRC: Transverse colectomy; LHC: Left hemicolectomy; SC: Sigmoid colectomy; AR: Anterior resection; TP: Total proctocolectomy; APR: Abdominoperineal resection; TRS: Transsphincteric resection were performed mainly on malignant diseases (88%). Zimmern et al[23] presented a retrospective review of 131 cases from their 4-year experiences of robotic colorectal surgery (Fig. 2). They reported that the robotic procedures included 42 right colectomies, 16 anterior resections for benign disease, eight anterior resections with rectopexy for prolapse, seven total proctocolectomies, 47 low and ultralow anterior resections for rectal cancer and 11 abdomino-perineal resections. Fourteen percent of a total of 954 colorectal resections were performed by robotic procedures. Although they did not present details, the indication for robotics seems to be diverse and its application broad.

At present, application of the robotic surgical system for total mesorectal excision (TME) seems to have the greatest potential for benefit, as it is expected to prove its ability when the operation is performed within a confined pelvis. The majority of recent studies have been focusing on robotic TME for rectal cancer.[29-36] According to kim et al[22] (Table 1), types of procedure are heavily weighted in favor of rectal cancer resection. In their institution, more than half of all rectal cancer patients have had robotic rectal resection since its introduction in their institute; 117 cases were performed by robotic surgery and 102 cases by laparoscopic surgery during the study period.[36]

Other procedures like right hemicolectomy or sigmoid resection are relatively straightforward procedures for the colorectal surgeon and can be effectively and safely performed using conventional laparoscopy.[37] Furthermore, after considering the higher medical cost and longer operating time, it is less attractive to implement robotic colorectal surgery except for TME in rectal cancer.[25,18,38] Some authors suggest alternative roles for the robot in the field of colon surgery, such as intracorporeal anastomosis, easier taking down of the splenic flexure, natural orifice specimen extraction or as a training tool.[20,26,35,38] It would be more appropriate to wait for more data from large randomized studies before a definite recommendation can be made.

Short-term clinical outcomes for robotic colorectal surgery such as operating time, conversion rate, length of hospital stay, morbidity and mortality are reviewed and compared with laparoscopic colorectal surgery.

In general, longer operating time is widely considered to be one of the disadvantages of robotic surgery, along with higher cost and lack of tactile sense, compared with conventional laparoscopic procedure. The robotic surgical system is still complex and bulky, and therefore a large operating room is needed and it takes significantly longer to prepare the device. Woeste et al[12] commented that the robot setup time has the tendency to remain long even after the initial learning curve. Because, some studies included setup time in the operating time.[20] The gap will be decreased if the robot setup time is considered. The operating time will also depend on whether the hybrid technique or totally robotic technique is utilized. Notably, although it is just a numerical difference, some authors have reported even shorter operating times for robotic rectal cancer resections using a hybrid technique.[30,31] Badani et al[17] reported their experience with 2,766 robotic-assisted radical prostatectomies and compared the results of their first 200 cases with their last 200 cases. The mean surgical and console times were 160 and 121 irrespectively in the first 200 cases; in the last 200 cases, they were 131 and 97 minutes respectively ($p = 0.05$). Since there is no large series in robotic colorectal surgery, we cannot be certain if the same conclusion can be reached. As we ascend the learning curve, achieving the prevention of any collisions with proper port placement and the standardization of every step of the procedure, the operating time can be expected to decrease further.

The excellent conversion rate has been reported consistently in several series of robotic rectal cancer surgery.[30,31,34-36] Although no statistically significant

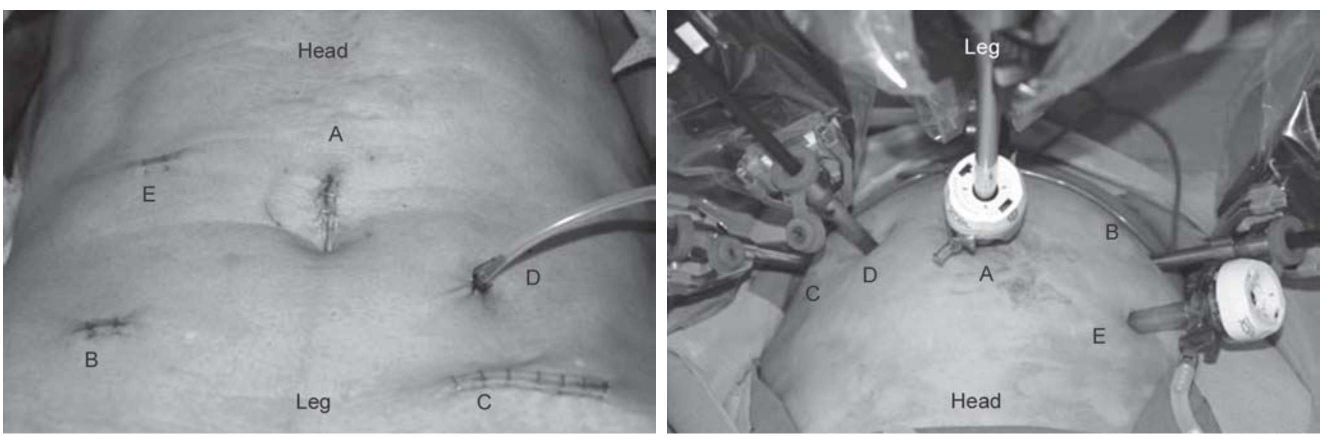

Fig. 2: Position of the working port for robotic low anterior resection. A: 12 mm camera port; B: 8 mm robot port. This port was exchanged with a 12 mm trocar to allow use of an Endo-GIA, C: 8 mm robot port; used for specimen delivery; D: 8 mm robot port; E: 11 mm port for assistance

differences were noted between the two groups in these studies, the zero conversion rates in robotic rectal cancer surgery are promising and encouraging when considering that reported conversion rates in laparoscopic rectal cancer surgery range from 12 to 20%.[39,40] Since, converted patients may have higher complication rates and worse oncologic outcomes,[41,42] these results can lead to better postoperative course and improved oncologic and functional outcomes.

The most frequent cause of conversions difficulty in pelvic dissection, which can cause bleeding from the lateral pelvic wall, rectal perforation and unintended injury to an adjacent organ. The most important technological advantage of the robotic surgical system is the ability to perform a fine dissection in a narrow pelvic cavity due to a stable, three-dimensional image and a freely articulating EndoWrist (Intuitive Surgical, Sunnyvale, CA, USA).

Similar outcomes of postoperative recovery between robotic and laparoscopic colorectal surgery were reported in most of the available publications.[18,20,26,27,32,35,36] Park et al[35] compared postoperative course in their case-matched analysis and showed no differences in first flatus passage (2.9 *vs* 2.7 days, $p = 0.487$), time to resume diet (6.7 *vs* 6.6 days, $p = 0.924$) and postoperative hospital stay (9.9 *vs* 9.4, $p = 0.527$). By contrast, Baik et al[30] in their nonrandomized comparative study of 56 robotic and 57 laparoscopic low anterior resections, reported shorter time to resume diet (4.7 *vs* 5.5 days, $p = 0.008$) and postoperative hospital stay (5.7 *vs* 7.6 days, $p = 0.001$). They presumed that the lower serious complication rates in the robotic group would influence the patients' recovery.

Surgical complications after robotic colorectal surgery have been documented in various previous studies but evaluating parameters also varied between the studies.[20,26,27,30,31,34-36] Nevertheless, robotic colorectal surgery seems to be equivalent to laparoscopic surgery in terms of overall operative complications. To the best of our knowledge, there was no report of postoperative mortality from robot-related complications.

As most studies are based on data from highly experienced laparoscopic colorectal surgeons, there is a definitive difference in the surgeon's expertise between the two operative techniques. We hypothesize that this difference may attenuate the benefits of robotic surgery, resulting in similar clinical outcomes rather than superior results due to its technological advantages. In view of the results achieved so far, robotic colorectal surgery can be performed safely and feasibly by the skillful laparoscopic surgeon.

Intraoperative blood loss has been reported in nine studies[13,17,20,25,26,43-45] with losses ranging from 21 to 400 ml. In one series, an instance of severe intraoperative hemorrhage following injury of a pelvic vein during a robotically assisted abdominoperineal resection is described, although it was considered unrelated to the robotic technique.[17] Conflicting results on blood loss have been found in studies comparing laparoscopic and robotic colorectal surgery. Delaney et al[25] and Woeste et al[44] both noted a nonsignificant increase in blood loss with robotic surgery. Rawlings et al found blood loss to be reduced in robotic right hemicolectomy, but increased in sigmoid colectomy when compared with laparoscopic resections. Other groups have also reported reduced blood loss with robotic colorectal procedures.[13,26,44,45] Biak et al[19] compared the mean change in hemoglobin concentration as a surrogate marker for blood loss. In their randomized study, they identified a nonsignificant reduction in blood loss in the robotic group.

SUMMARY

Current evidence suggests that the safety and feasibility of robotic colorectal surgery has been established. The advantages conferred by the robot are particularly useful for rectal dissection. Although the majority of published studies are case series or nonrandomized comparative studies, data show equivalent clinical short-term outcomes except for longer operating times and lower conversion rates compared with laparoscopic surgery. However, the lack of prospective randomized studies precludes definitive conclusions. Multicenter, prospective randomized controlled trials designed to evaluate safety, feasibility, cost-effectiveness and long-term outcomes will provide crucial information on the practice of robotic colorectal surgery.

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REVIEW ARTICLE

Role of Robotics in Whipple's Surgery

B Srinivas

ABSTRACT

Whipple is one of the most demanding and complex surgeries of the abdomen. It is the most commonly performed operation for pancreatic cancer, the fourth leading cause of cancer death in the United States. For patients with benign as well as malignant pancreatic tumors, it is believed that the robotic Whipple procedure will be a major improvement over the traditional procedure. The robotic surgery involves five small incisions (one to accommodate a miniature camera), rather than a large incision and separation, not cutting of muscles.

Keywords: Robotic Whipple's surgery, Robotic surgery, Da Vinci Whipple's surgery.

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INTRODUCTION

A robotic device is a powered, computer-controlled manipulator with artificial sensing that can be reprogrammed to move and position tools to carry out a wide range of tasks.[1] Telemanipulators and robots were first developed by the National Aeronautics and Space Administration (NASA) for use in space exploration. In 1985, NASA instituted a research program in telerobotics to develop the technology for the United States Space Program.[2]

The medical robotic systems of present generation are the brainchild of the United States Department of Defence's desire to decrease war casualties with the development of 'telerobotic surgery'. The 'master-slave' telemanipulator concept was developed for medical use in the early 1990s where the surgeon's (master) manual movements were transmitted to end-effector (slave) instruments at a remote site. The field of surgical robotics has undergone massive transformation since then and the future is even brighter.[2]

Robotically-assisted surgery was developed to overcome the limitations of minimally invasive surgery.

Methods of controlling the instruments in robotic surgery:

1. Telemanipulator
2. Computer-controlled system

A telemanipulator is a remote manipulator that allows the surgeon to perform the normal movements associated with the surgery, while the robotic arms carry out those movements using end-effectors and manipulators to perform the actual surgery on the patient.

In computer-controlled systems, the surgeon uses a computer to control the robotic arms and its end-effectors, though these systems can also still use telemanipulators for their input. One advantage of using the computerized method is that the surgeon does not have to be present, indeed the surgeon could be anywhere in the world, leading to the possibility for remote surgery.

HISTORY

- 1985: A robot, the PUMA 560, was used to place a needle for a brain biopsy using CT guidance.[3,4]
- 1988: The PROBOT, developed at Imperial College London, was used to perform prostatic surgery.
- 1992: The ROBODOC from Integrated Surgical Systems was introduced into mill out precise fittings in the femur for hip replacement.[9]
- 1997: A reconnection of the fallopian tubes operation was performed successfully in Cleveland using ZEUS.
- May 1998: Dr Friedrich Wilhelm Mohr using the da Vinci surgical system performed the first robotically assisted heart bypass.
- September 2010: The Eindhoven University of Technology announced the development of Sofie surgical system, the first surgical robot to employ force feedback.

  The intuitive surgical introduced the da Vinci surgical system and computer motion with the AESOP and the ZEUS robotic surgical system. (Intuitive surgical bought computer motion in 2003; ZEUS is no longer being actively marketed).[5-7]

Three main types of surgical robots available at present are as follows:

1. Supervisory-controlled Robotic Surgery Systems (e. g. the ROBODOC® system from CUREXO Technology Corporation): It is the most automated surgical robots available till date. Surgeons can plan their surgery preoperatively in a 3D virtual space and then execute the surgery exactly as planned in the operating theater.
2. Shared-control Robotic Surgery Systems: These robots aid surgeons during surgery, but the human does most of the work.
3. Telesurgical devices: Here, the surgeon directs the motions of the robot, e.g. the da Vinci robotic system, the ZEUS surgical system.

The da Vinci surgical system comprises three components:

- A surgeon's console,
- A patient-side robotic cart with four arms manipulated by the surgeon (one to control the camera and three to manipulate instruments), and
- A high-definition 3D vision system. Articulating surgical instruments are mounted on the robotic arms which are introduced into the body through cannulas.

Three generations of da Vinci surgical systems have developed so far:[8]

1. *da Vinci surgical system (1999):* It consists of three components: The viewing and control console, surgical arm unit (three or four arms depending on the model) and optical three-dimensional vision tower (Figs 1A to C).
2. *da Vinci S HD surgical system (2006):* This second generation surgical robot is equipped with wide range of motion of robotic arms and extended length instruments, interactive video displays and touch screen monitor.
3. *da Vinci Si HD surgical system (2009):* It has dual console capability to support training and collaboration, advanced 3D HD visualization with up to 10× magnification, 'EndoWrist'® instrumentation with dexterity and range of motion more than the human hand and 'Intuitive® motion technology'(Figs 2A and B), which replicates the experience of open surgery by preserving natural eye-hand-instrument alignment.[8] The new da Vinci HD SI released in April, 2009 currently sells for $1.75 million.

SYNONYMS

- Robotic surgery
- Computer-assisted surgery
- Robotically-assisted surgery.

AIM OF STUDY

The aim of this review article is to appraise and to evaluate the present and future role of robotics in Whipple's surgery. The following parameters were evaluated:

1. Patient and disease factors
2. Technical considerations
3. Operating time
4. Intra- and postoperative complications
5. Postoperative morbidity
6. Hospital stay
7. Cost-effectiveness
8. Quality of life analysis.

MATERIALS AND METHODS

A literature search was performed using search engine google, Springer, HighWire, Sages, IJA, PubMed, etc. and the literature analyzed.

KEYWORDS

- da Vinci robotic system
- Robotic Whipple
- Robotic pancreaticoduodenectomy
- Robotic surgery
- Minimally invasive surgery
- Pancreatectomy
- Pancreatic resection
- Pancreaticoduodenectomy
- Whipple's surgery.

CARCINOMA OF THE PANCREAS AND PERIAMPULLARY AREA

Essentials of diagnosis:

- Obstructive jaundice (may be painless)
- Enlarged gallbladder (Courvoisier's sign)

Figs 1A to C: (A) The da Vinci system surgeon console (B) The cart with three mounted surgical arms (C) joysticks with viewing ports in the console (*courtesy:* Intuitive Surgical Inc, Sunnyvale, CA)

- Upper abdominal pain with radiation to back, weight loss and thrombophlebitis are usually late manifestations.

Risk factors for pancreatic cancer:
- Age
- Obesity
- Tobacco use
- Family history
- Heavy alcohol use
- Chronic pancreatitis
- Prior abdominal radiation
- Previous H/O partial gastrectomy.

GENERAL CONSIDERATIONS

Ductal adenocarcinoma is the most common neoplasm of the pancreas. Other neoplasms of pancreas include:
- Mucinous cyst adenocarcinoma
- Serous cyst adenoma
- Mucinous cyst adenoma
- Malignant exocrine tumors
- Benign exocrine tumors
- Endocrine
  – Gastrinoma
  – Insulinoma.

Carcinomas involving the head of the pancreas, the ampulla of Vater, the distal common bile duct and the duodenum are considered together, because they are usually indistinguishable clinically; of these, carcinomas of the pancreas constitute over 90%. About 75% are in the head and 25% in the body and tail of the organ. They comprise 2% of all cancers and 5% of cancer deaths. Risk factors include new-onset diabetes mellitus after the age of 45 years, occasionally heralds the onset of early pancreatic cancer.

IMAGING

CT scan: A multiphase helical CT scan is the initial diagnostic tool and detects a mass in more than 80% of cases.
- Endoscopic ultrasound
- PET scan
- MRI
- ERCP
- MRCP.

WHIPPLE'S SURGERY

Whipple's surgery is done for:
- Cancer of the head of the pancreas
- Cancer of the duodenum
- Cholangiocarcinoma (cancer of the pancreatic end of the bile)
- Cancer of the ampulla
- Whipple operation may also sometimes be performed for patients with benign (noncancerous) disorders such as chronic pancreatitis and benign tumors of the head of the pancreas.

Advantages of Robotic Whipple

The robotic Whipple offers patients a minimally invasive option to the traditional surgeries for pancreatic cancer and benign tumors of the pancreas and colon, resulting in the potential for:
- Less pain
- Shorter hospital stays
- Faster recovery times
- Minimized scarring
- Blood loss
- Less complications.

Figs 2A and B: (A) New generation robotic instruments have seven degrees of freedom as the human hand, (B) EndoWrist® instrument from intuitive surgical (*Courtesy:* Intuitive Surgical Inc, Sunnyvale, CA)

LIMITATIONS OF ROBOTIC-ASSISTED SURGERY

Patient safety in the event of robot malfunction and crash down is a concern and the operating room staff should be aware of it. Robotic technology is a complex issue and needs a lot of practice and technical expertise. Robotic surgery needs longer operating room time compared with conventional surgeries. Several pieces of equipment, each being extremely bulky, require large operating room space.[11]

The staff must be trained and prepared to quickly detach and remove the robot from the patient in the event of an emergency. Current robotic systems lack tactile feedback from the instruments.[12]

Surgeons have to rely on visual clues to modulate the amount of tension and pressure applied to tissues to avoid organ damage. The newly launched da Vinci HD SI system costs $1.75 million. Initial increased operating room setup time and surgical time adds to the cost burden. However, robot- assisted surgery has shown to reduce hospital stay by about half and thereby cutting hospital cost by about 33%.[13]

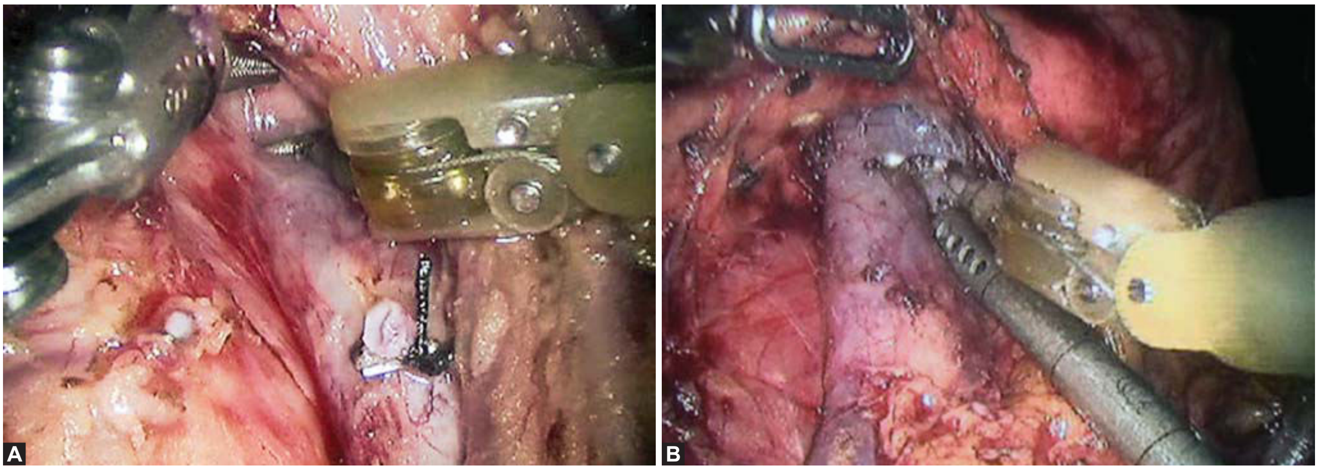
One major obstacle to the telerobotic surgery is the 'latent time', which is the time taken to send an electrical signal from a hand motion to actual visualization of the hand motion on a remote screen. Humans can compensate for delays of less than 200 msec[14] (Table 1). Longer delays compromise surgical accuracy and safety. Incompatibility with imaging equipment is an area that needs attention.

THE STEPS IN A ROBOTIC WHIPPLE PROCEDURE[10] (FIGS 3 TO 5)

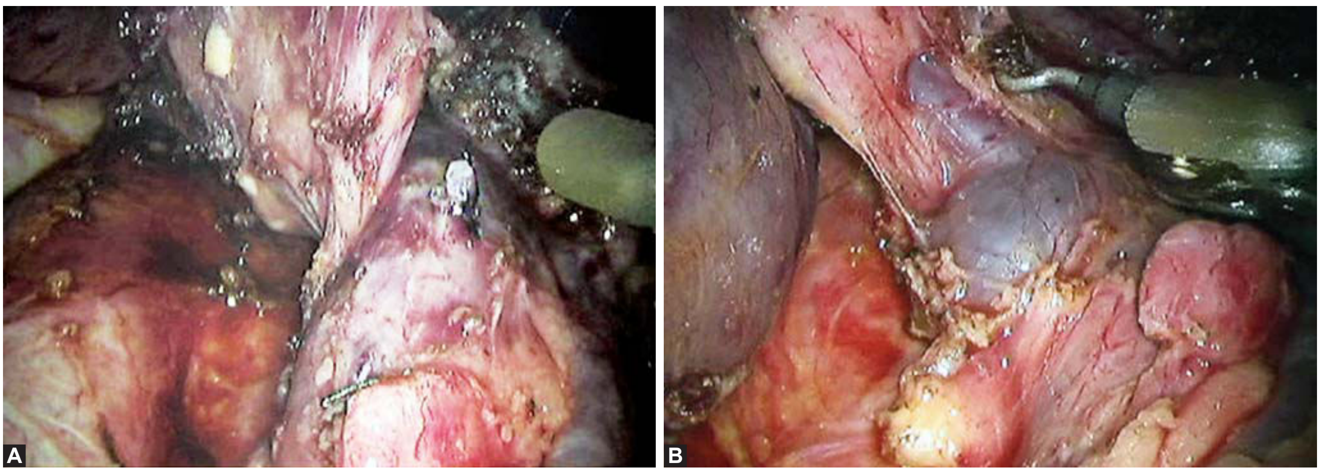
1. *Preoperative considerations: Patient and disease factors:*
   - Preoperative evaluation of acute or chronic pancreatitis which if present makes robotic dissection difficult
   - The presence of a replaced right hepatic artery and the position of the 1st jejunal vein (J1) branch, as it enters the right side of the superior mesenteric vein, should be assessed in order to avoid any inadvertent injury
   - Short stature and obesity create excess intra-abdominal fat which makes robotic dissection difficult.
2. *Laparoscopy, port setting and robot docking:* A laparoscopic investigation of the abdominal cavity is essential prior to any major pancreas tumor resection (NCCN guidelines). The laparoscopy not only allows surgical staging, but also allows identification of acute or chronic pancreatitis, an unfavorable body habitus or other unforeseen obstacles to a robotic procedure.[10]
   Robotic trocar placement: The camera port is positioned slightly to the patient's right side and inferior to the umbilicus. The camera port is approximately 18 cm from the operative focus, and the robotic axis is slightly to the patient's right side of midline. The right robotic arm is placed in the upper left-hand corner of the abdomen. The robotic left hand is in the patient's left lower quadrant, with the robotic 3rd arm below the patient's right costal margin (after pneumoperitonealization). Assistant operating ports are positioned in the right and left abdominal quadrants. The robotic ports should be 8 to 10 cm apart, if possible, while the assistant ports should be at least 5 cm from additional port sites.[10]
3. Mobilization of duodenum (kocherization) and exposure of the superior mesenteric/portal vein
4. Exploration of the porta hepatis
5. Mobilization of the ligament of Treitz
6. Transecting the pancreas and dissecting the uncinate process
7. Reconstruction: Pancreaticojejunostomy, hepatico-jejunostomy and gastrojejunostomy.

Table 1: Advantages and disadvantages of conventional laparoscopic surgery *vs* robot-assisted surgery

	Conventional laparoscopic surgery	*Robot-assisted surgery*
Advantages	Well-developed technology Affordable and ubiquitous Proven efficacy	3D visualization Improved dexterity Seven degrees of freedom Elimination of fulcrum effect Elimination of physiologic tremors Ability to scale motions Microanastomoses possible Telesurgery Ergonomic position
Disadvantages	Loss of touch sensation Loss of 3D visualization Compromised dexterity Limited degrees of motion The fulcrum effect Amplification of physiologic tremors	Absence of touch sensation Very expensive High start-up cost May require extra staff to operate New technology Unproven benefit



Figs 3A and B: Creation of the retropancreatic tunnel, along the anterior border of the superior mesenteric vein and portal vein confluence. Dissection is completed under direct visualization, which is facilitated by the position of the robotic camera. Completing the tunnel under direct visualization improves the safety of the Whipple procedure[10]



Figs 4A and B: (A) Elevation of the pancreatic head and uncinate process in an anterior fashion out of the retroperitoneum. The superior mesenteric vein and portal vein confluence is visualized in the center of the photograph. The elevation of the pancreatic tissue allows excellent visualization of the uncinate process and its retroperitoneal attachments. (B) As the uncinate process is mobilized from the retroperitoneum, the Wrst jejunal vein branch must be anticipated. The photograph illustrates the 1st jejunal vein, with the vein branch entering the inferior portion of pancreatic head[10]

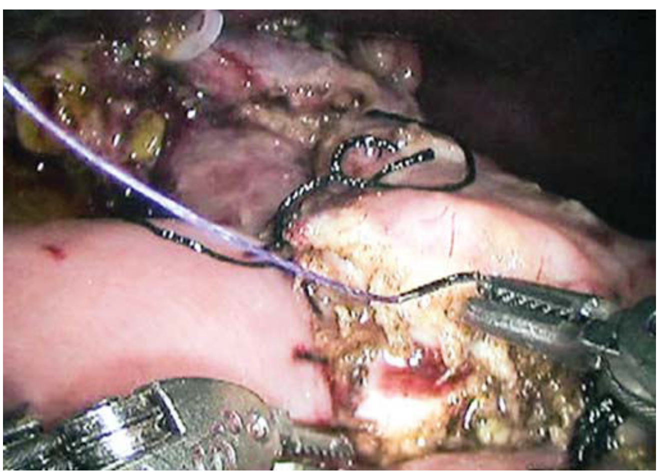


Fig. 5: Suturing of the pancreatic duct during the pancreaticojejunostomy creation. The duct-to-mucosa anastomosis is created with a 4-0 Vicryl suture on an RB1 needle. The pancreas parenchyma and pancreatic duct are seen on the right side of the photograph, while the jejunum is visualized on the left[10]

LITERATURE REVIEW

Whipple procedure remains a standard surgical procedure for periampullary carcinoma.[16]

Since the first laparoscopic cholecystectomy in 1989, minimally invasive surgery has become the alternative approach to conventional open surgery in many abdominal procedures.[17] In early laparoscopic years, most surgeons used only diagnostic laparoscopy to evaluate periampullary malignancies or staging pancreatic cancer.[18] With the benefit of minimal invasive surgery and new advances in technology and instrumentation, some surgeons began to apply it to more sophisticated procedures such as Whipple procedure.[19]

Gagner and Pomp reported the first laparoscopic Whipple procedure in 1994.[20] However, because of the technical difficulty, not many laparoscopic Whipple procedures were performed. Several prospective randomized

Table 2: Advantages and disadvantages of robot-assisted surgery *vs* conventional surgery

Human strengths	*Human limitations*	*Robot strengths*	*Robot limitations*
• Strong hand-eye coordination • Dexterous • Flexible and adaptable • Can integrate extensive and diverse information • Rudimentary haptic abilities • Able to use qualitative information • Good judgment • Easy to instruct and debrief	• Limited dexterity outside natural scale • Prone to tremor and fatigue • Limited geometric accuracy • Limited ability to use quantitative information • Limited sterility • Susceptible to radiation and infection	• Good geometric accuracy • Stable and untiring • Scale motion • Can use diverse sensors in control • May be sterilized • Resistant to radiation and infection	• No judgment • Unable to use qualitative information • Absence of haptic sensation • Expensive • Technology in flux • More studies needed

trials showed no difference in leakage and fistula rate between pancreaticogastrostomy and pancreaticojejunostomy.[21-23] The duct to mucosa technique was utilized for both pancreaticogastrostomy and hepaticojejunostomy. Such a technique showed low or at least the same rate of leakage compared to the conventional method.[24,25]

Two major concerns that anticipate early adoption of laparoscopic Whipple comprised of the difficult surgical technique, resulting in a long operative time, as well the oncologic question about the adequacy of the laparoscopic operation.[19,26] To shorten the learning curve of laparoscopic approach, the hand-assisted hybrid technique had been used with favorable results Table 2. Recently, robotic Whipple using the da Vinci system has also been shown to be feasible and efficient.[27]

All the benefits of minimally invasive surgery may be expected from the robotic Whipple procedure. Patients undergoing robotic procedure mobilize earlier than their open counterparts. The median length of hospital stay is 6.2 days (range, 5.2-18.8), which compares favorably to open Whipple procedure,where the median length of hospital stay is 7.9 days.[10] One of the principal objections to the robotic procedure is the increased duration of operating time. The mean robotic operating time is 8 hours (range 5.9-9.6), which again compares favorably open surgery where the mean operating time is 5.4 hours.[10]

The robotic Whipple needs to conform to the standards that have been set and validated for an open Whipple. Modifications and/or shortcuts to allow for use of the robot should be avoided if the robotic resection cannot be performed to a similar standard to the open procedure, then the procedure needs to be converted.

Giulianotti et al have reported a series of eight patients in whom pancreaticoduodenectomies were performed completely laparoscopically with the assistance of the robot. In this advanced technique, the hepaticojejunostomies and gastrojejunostomies were handsewn intracorporeally and the remnant pancreatic duct was injected with surgical glue.[28]

Whether the current-generation surgical robot is advanced enough to allow routine performance of pancreatic head tumor resections remains to be seen. In an operation like the Whipple procedure, where we rely so heavily on blind palpation for careful dissection of the portal vein off the posterior pancreatic surface, it is possible that the da Vinci's lack of haptic feedback may preclude its safe application.[28-30]

CONCLUSION

Robotic-assisted minimally invasive pancreaticoduodenectomy can be performed safely and effectively with significant individual and institutional preparation and commitment. Safety is directly related to the surgical team's ability to complete the operative procedure in an open fashion, and a breadth of experience dealing with complex interoperative hepatobiliary complications. If oncological principles and/or safety are compromised, the procedure needs to be converted to a standard open Whipple.[10]

The patient requires an upfront frank preoperative discussion regarding the novel approach of the minimally invasive pancreaticoduodenectomy.[15] Informed consent can be obtained if the benefits, risks and the alternatives—an open procedure—are discussed in detail. The robotic team should consist of expert pancreas and skilled robotic surgeons, nurses and operating room technicians. When the surgical team is motivated to push the frontiers of pancreas surgery, the patient will benefit from the minimally invasive procedure.

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REVIEW ARTICLE

Ureteral Injury in Gynecologic Laparoscopy

Gina Sternschuss

ABSTRACT

Purpose: To review incidence, presentation, diagnostic methods, management, significance and avoidance of ureteral injuries in gynecologic laparoscopy.

Materials and methods: PubMed, National Center for Biotechnology Information Database, Journal of the Society of Laparoendoscopic Surgeons, obstetrics and gynecology journal, google images were reviewed to gather information regarding ureteral injuries in gynecologic laparoscopy.

Results: Ureteral injury is one of the serious complications of laparoscopic surgery, in particular, gynecologic laparoscopy. It is very important to be familiar with presentation, diagnostic methods and management as well as prevention of ureteral injury at the time of gynecologic laparoscopy.

Conclusion: Every gynecologic surgeon has to be familiar with signs and symptoms as well as management of ureteral injury at the time of gynecologic laparoscopy.

Keywords: Gynecologic laparoscopy, Ureteral injury, Ureteral stenting.

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INTRODUCTION

Laparoscopic gynecologic surgeries have a clear advantage over open surgeries and considered to be more beneficial for the patients since patients undergoing laparoscopic gynecologic surgeries return to normal activities quicker, have shorter hospitalizations, fewer infections, lower overall blood loss and less postoperative pain.[1] Laparoscopic procedures are generally safe, effective and well tolerated by the patients.[2] But, e.g. laparoscopic-assisted vaginal hysterectomy from lap hyst paper has higher risk of bladder and ureter injury than abdominal hysterectomy.[3] Overall rate of lower urinary tract injury during gynecologic laparoscopy is 3 to 4%.[4] Injury to the lower urinary tract leads to increase in patient's morbidity and mortality as well as decrease in quality of life.

Urological injury is a very serious complication in gynecological laparoscopic operations. It is associated with the morbidity of vesicovaginal fistula, ureteric stenosis as well as hydronephrosis with variable degrees of renal impairment and failure may occur.

Urological injury can also be the basis of medicolegal suits.

It is an important concern for gynecologists, and can happen to inexperienced as well as to experienced gynecologic surgeons. Awareness, as well as early recognition and detection of the possibility of urologic injury is paramount of safe gynecologic laparoscopic surgery.[5]

Most common sites of ureteric injury during gynecologic laparoscopy are at the level of pelvic brim, near the infundibulopelvic ligament, and at the level where the ureter passes beneath uterine artery.

Factors associated with increased incidence of ureteric injury are the conditions leading to the distortion of the pelvic anatomy, such as extensive endometriosis, pelvic adhesions, presence of large pelvic mass.[5]

Noteworthy that almost half of ureteric injuries occurring during laparoscopic hysterectomy, occur during simple, uncomplicated hysterectomy.[6] Some investigators found that ureteral injury during laparoscopy most commonly occurs near the uterosacral ligaments.[7]

Some surgeons routinely dissect the ureter, exposing its course retroperitoneally, although it is also not without drawbacks, such as risk of injury to the major vessels on the pelvic sidewall. Some surgeons routinely stent the ureters, but stenting the ureters has not been shown to decrease the risk of ureteral injury (Fig. 1). In fact, presence

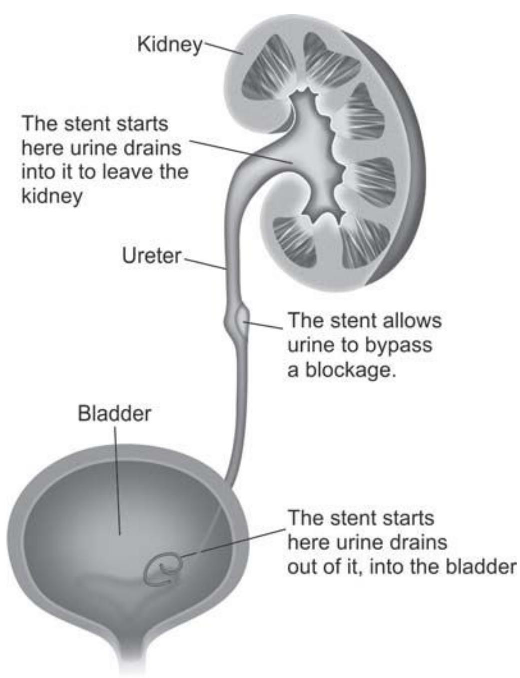

Fig. 1: Ureteral stenting[14]

of ureteric stent may increase the injury to the ureter during laparoscopic dissection.[8]

Ureteral damage is usually caused by one of the three ways-either by direct injury from clamping, cutting, ligating or kinking in an attempt to stop the hemorrhage deep in the pelvis, by stripping ureter of its periurethral sheath devoiding it from its blood supply thereby creating postoperative damage, or by use of electrosurgery.[9]

One of the issues in laparoscopic surgery is a wide-spread use of electrosurgery during dissection, during development of tissue planes, during exposure of the pedicles and such. Good understanding of principles of electrosurgery is imperative for the safe laparoscopic surgeon (Fig. 2).

Issues such as difference between monopolar and bipolar energy, direct coupling, and lateral thermal spread have to be kept in mind. Blind use of electrosurgery without first identifying exact source of bleeding near uterine artery, for example, can lead to ureteral injury and create other complications.

Routine cystoscopy during laparoscopic gynecologic surgery allows for detection of more urinary tract injuries than without use of routine cystoscopy. The rate of injury to the ureter increases from 7.3 per 1,000 surgeries to 14.5 per 1,000 surgeries when routine intraoperative cystoscopy is employed.[10] Intraoperative cystoscopy with intravenous indigo carmine is a simple way to detect lower urinary tract injury, such as injury to the ureter and the bladder. It is highly recommended to ensure absence of injury to the lower urinary tract.[11] Early recognition and repair is the key to successful recovery.[5]

Manifestations of ureteral injury usually seen early after the surgery (48-72 hours postoperatively). Patients present with signs and symptoms of peritonitis that is accompanied by nausea, vomiting, abdominal pain, fever and leukocytosis. Sometimes flank tenderness and hematuria are also observed. IVP is a diagnostic method of choice in patients where ureteral injury is suspected.

There are several methods to deal with ureteral injury after laparoscopic surgery. A small laceration, not leading to the transaction of the ureter, can be managed with an insertion of ureteric stent and 1 suture closing the defect may be placed, if an injury has been recognized intraoperatively.[12] Most commonly, if ureteral damage is minimal, ureteral stenting is sufficient. Sometimes exploratory laparotomy with reimplantation of the ureter into the bladder, anastomosis of the damaged ureter, transureteral ureterostomy, interposition of the loop of ileum between the ureter and the bladder may be required (Figs 3 and 4).[13]

Occasionally, ureteral injury after laparoscopy presents late in patient's postoperative course (3-33 days post-operatively). The presenting symptoms are similar to early recognized ureteral injuries, such as nausea, vomiting, fever, flank pain and peritoneal signs-abdominal distension, abdominal pain, ileus as well as diffuse urinary peritonitis due to urinary ascites. Blood test shows an increase in creatinine level. If ureteral injury remains undetected until late in postoperative course, obstruction and fistula may occur. Ureteral stricture may also develop that makes ureteral stenting very difficult. So, delayed recognition of ureteral injury in gynecologic laparoscopy associated with serious complications and treatment with ureteral stenting is not useful. Exploratory laparotomy with one of the methods of repair mentioned above, usually indicated.[7]

Prevention of lower urinary tract injury and particularly ureteral injury, during gynecologic laparoscopy can be minimized by thorough knowledge of pelvic anatomy, identification of the course of the ureter intraoperatively (Fig. 5), and knowledge of it's location at all times during the dissection, keeping in mind most common sites of ureteral injury, understanding principles of electrosurgery as well as use of correct and safe operative techniques (Fig. 6).

Fig. 2: Electrosurgical generator used in gynecologic laparoscopy[14]

Fig. 3: Ureteral reimplantation[14]

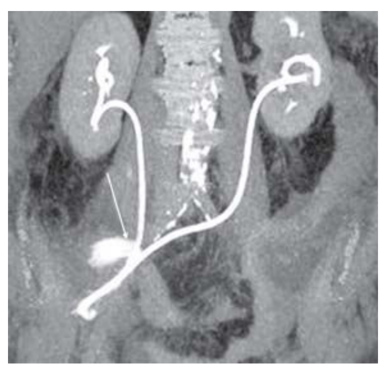

Fig. 4: Ureteral anastomosis[14]

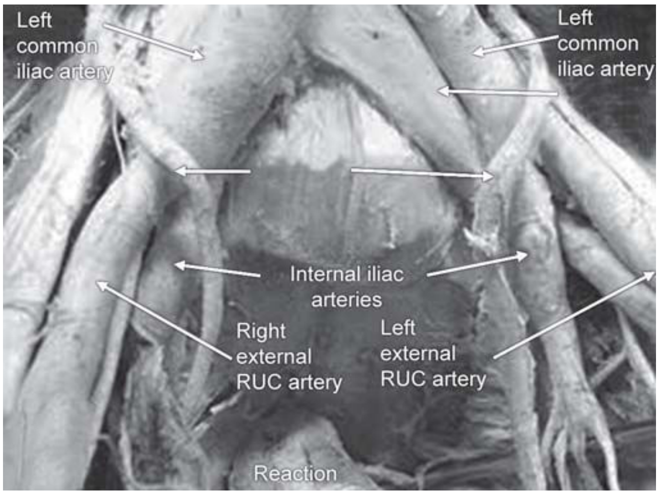

Fig. 5: Course of the ureter in the pelvis[14]

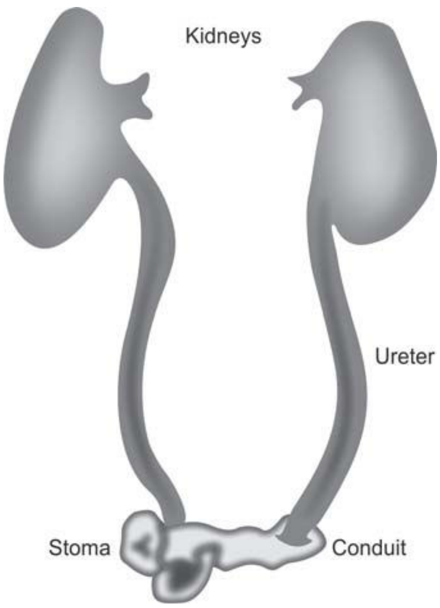

Fig. 6: Ureteral ileal conduit[14]

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REVIEW ARTICLE

Is Robotic Pancreatic Surgery expected Access by the Minimal Access Pancreatic Surgeons?

RJ Orti-Rodríguez

ABSTRACT

Objectives: Many surgeons have demonstrated the feasibility of laparoscopic pancreatoduodenectomies (PD), but benefits comparable to or even more prominent than those of an open procedure has not been clinically proven. Robotic surgery has improved some aspects of the laparoscopic approach. We compare both types of approach for PD.

Methods: The literature was systematically reviewed to find all the PD procedures totally performed by a laparoscopic or by a robotic approach.

Results: Between 1996 and 2012, 192 patients underwent a total laparoscopic PD and 109 a total robotic PD. The mean operating room time and mean estimated blood loss was 388.8 minutes and 178.7 ml for LG and 397.4 minutes and 319.06 ml for RG. Morbidity was found in 18 cases of RG and in 69 of LG. Mortality and conversion rates were similars in both arms.

Conclusion: This review can not find clear difference between both groups in spite of the short literature available.

Keywords: Laparoscopic, Robotic, Pancreatoduodenectomy, Whipple.

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INTRODUCTION

Even in unresectable pancreatic neoplasms, staging or palliation can be accomplished by laparoscopic means. It is well known that the morbidity of a large laparotomy, which is required for an adequate exposure, can be avoided with laparoscopic examination and ultrasonography for staging, laparoscopic palliative bypass surgery or thoracoscopic splanchnicectomy for pain control.

But, what about minimal access pancreatic resection for pancreatic cancer? Surgical resection in nonadvanced pancreatic neoplasms represents the only hope of cure. The definitive surgical procedure for carcinoma of the head of the pancreas is the Whipple pancreaticoduodenectomy (PD), and for some time now, pylorus-preserving PD is replacing standard Whipple PD because a better gastric emptying may result in better nutrition and weight gain. Although debate continues, the open approach continues to enjoy decreasing rates of morbidity and mortality around the world, of course, when the procedure is performed by experienced surgeons in referral centers.

At the same time, minimal access techniques are in a high-speed development day by day, minute by minute and second by second. Once a surgical technique is not fully demonstrated yet, another new access technique approach or even instrument is born. In pancreatic surgery there is increasing interest in the feasibility of minimal access techniques in an attempt to decrease morbidity. But, the difficulty of performing these complex resections and reconstructions without the whole freedom of movement of the open surgery can cast doubt on the suitability of the laparoscopic approach.

Robotic surgery, an unstoppable field of the minimal access surgery, has improved some limitations of standard laparoscopic surgery such, among other things, ergonomic, precision suturing and of course tha lack of three-dimensional visualization. So, is robotic surgery the step we were expecting for minimal access PD?

In this review, we present the current evidence available on minimal access PD comparing both techniques to sort out this question.

METHODS

Search Strategy

The PubMed database was searched electronically from 1996 up to January 2011 (inclusive). Search terms used included: Laparoscopic, robotic, Whipple procedure, pancreaticoduodenectomy, pancreatoduodenectomy. Terms were searched both in isolation and in combination. Search limits were applied to include articles published in English or in Spanish languages and human studies only. Articles published in abstract form only, single case reports, review articles or reporting less than five cases were not included for the final analysis. Cases describing hand assistance as part of the procedure or hybrid approaches are also excluded in this study because were not considered as just one pure approach (total laparoscopic or total robotic PDs). For authors or institutions who republished their results with larger series, only the most recent article and larger series were included. To achieve a more homogeneous data collecting, series of patients from multicentric studies were taken, when the information reported allowed, as independent series according to the institution. Flow chart outlines the search history and the total number of publications included in this review.

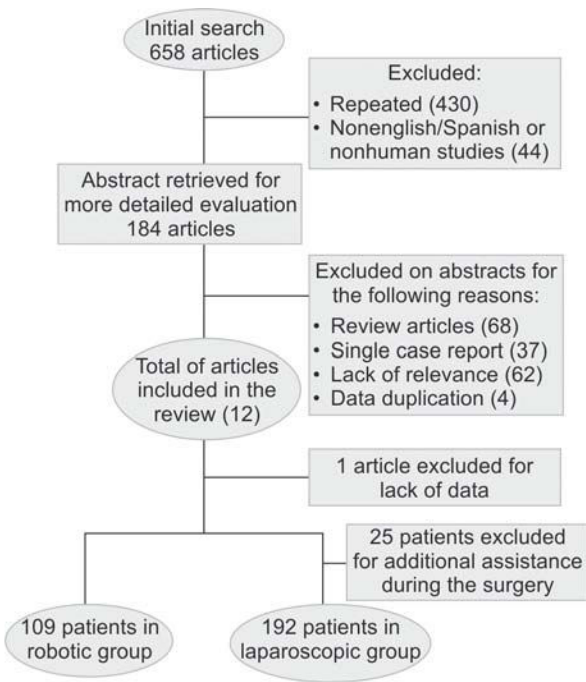
The variables studied were as follows: Mean operating room time, mean estimated blood loss, morbidity, bleeding, fistulas rates, mortality and conversion rates.

RESULTS

The initial search identified 658 articles. After exclusion of repeated articles 228 and items not published in English or Spanish languages or no humans studies, 44, 184 publications were selected. All identified articles were examined, and manuscripts with one or more exclusion criteria were not taken into account—review articles 68, single case reports 37, lack of relevance 62, data duplication 4.

During the process of data collection, we found an article with a large series of 35 patients[1] in which there were not reported most of the variables examined, therefore, we finally excluded it in spite of it is mentioned and used in other review articles.[2] At the end, a total of 12 articles were full examined.

In the examined publications, there were no randomized controlled trials and a total of 326 patients were included in from all articles; 217 patients for the laparoscopic group (LG) and 109 for the robotic group (RG). In 25 patients (LG), an additional assistance was necessary as a minilaparotomy or a hand-port to perform the whole reconstruction, so these patients were excluded of the study. Of the remaining 301 patients the conversión rates were 29 (9.6%; LG = 16 (8.3%); RG = 13 (12%)) and were taken as technique fails.



Flow Chart 1: The search history and total number of publications included

A weighted average (WA), utilized also by Gumbs et al in a recent review, is used to calculate a statistical weighted mean of all the differents means collected in the examined publications:

$$WA = (w_1x_1 + w_2x_2 + \ldots + w_nx_n)/(w_1 + w_2 + \ldots + w_n)$$

where w is the number of cases in a publication and x is the mean of an specific variable.

Tables 1 and 2 summarise the outcomes of total laparoscopic and total robotic PD respectively.

PERIOPERATIVE FACTORS

Mean operation time ranged from 287 to 628 minutes in LG and from 312 to 718 minutes in RG, with a WA of 389 (LG) and 394 minutes (RG). Mean estimated blood loss ranged from 74 to 770 ml in LG, but this variable was not reported in 10 cases (5%) which were not taken into account in the analysis. Notice that the lowest estimated blood loss is in the largest series as Palanivelu's series and most of them are under 300 ml of blood loss. WA calculated was 178.7 ml. In the robotic arm WA was 319 ml with a range from 153 to 389 ml. All of the groups reported hospital stay. Average length of stay in LG ranged from 7 to 22.3 days with a WA of 10 days. The lowest limits of this range is from the group of Minnesota, the largest and one of the most recent series in this analysis. In RG, we found a considerable increase in the length of stay, ranged from 9 to 22 days and with a WA of 15 and 31 days.

Morbidity

Perioperative complications occurred in LG in 69 patients (36%). We have stressed the importance of two specific types of morbidity: Bleeding and fistulas and we have not paid attention to gastric emptying because we are not going to differentiate standard Whipple´s procedure with pylorus-preserving PD. It is important to enhance that in RG total morbidity is not representative because of the absence of the largest series data (60 patients; 55%).

Bleeding

Bleeding is considerated as an unexpected blood loss during the surgery or the whole postoperative hospital stay which required any surgical or medical management and is not directly derivated from another medical or nonmedical intervention. Anemia as incidental finding was not considerated as bleeding although blood transfusions were required. Just one group did not report this data (42 patients; 26.4%) but we decided to count it as if they did not suffer any bleeding because of the fact that the author reported a detailled morbidity without the necessity of mention this parameter.[3] Bleeding was identified in eight (4%) of 192 of the patients of the LG and in nine cases (9%) of 101 patients

Table 1: Total laparoscopic pancreaticoduodenectomies (NR: Nonreported)

Study	*Year*	*Patients*	*Mean operative time (min)*	*Mean estimated blood loss (ml)*	*Mean hospital stay (days)*	*Morbidity cases*	*Mortality cases*	*Conversion cases*
Gagner[12]	1997	10	510	NR	22	3	NR	4
Dulucq[21]	2006	16	287	107	16	4	1	3
Lu[22]	2006	5	528	770	NR	2	1	1
Palanivelu[3]	2007	75	357	74	8	20	1	0
Pugliese[23]	2008	12	461	180	19	4	0	6
Kendrick[13]	2010	54	368	240	7	26	1	0
Ammori[14]	2011	6	628	350	11	2	0	0
Zureikat[24]	2011	14	456	300	8	8	1	2
Total/mean		192	388.8	178.7	9.9	69 (35.9%)	5 (2.7%)	16 (8.3%)

Table 2: Total robotic pancreaticoduodenectomies (NR: Nonreported)

Study	*Year*	*Patients*	*Mean operative time (min)*	*Mean estimated blood loss (ml)*	*Mean hospital stay (days)*	*Morbidity cases*	*Mortality cases*	*Conversion cases*
Buchs[17]	2010	41	430	389	13	16	1	2
Giulianotti (IT)[4]	2010	36	312	261	22	NR	1	9
Giulianotti (USA)[4]	2010	24	351	342	9	NR	1	2
Zhou[25]	2011	8	718	153	16	2	0	0
Total/mean		109	394.77	319.06	15.31	18 (21%)	3 (3%)	13 (12%)

reported in RG with a good control in all of the cases in both arms.

Fistula

We do not use an specific international definition of postoperative pancreatic fistula (PPF) due to the varied definitions used by the differents authors, although most of them adopted the international study group on pancreatic fistula definition. Furthermore, to emphasize the difficulty of the reconstruction, we joined all the anastomosis leaks (pancreatic, biliary and digestive) in just one variable for the final analysis. The most common fistula reported was PPF. We identified 28 cases (14.5%) from the LG and 33 (30%) in RG in which at least one total intracorporeal anastomosis presented a leak.

Mortality

Operative mortality was defined as death within the period of time from the surgery until the discharge. All the studies reported their mortality apart from one with 10 cases which were not taken into account in the analysis. We found five patients (2.7%) who died during the hospital stay, most of them due to an advanced septicemia condition secondary to pancreatic fistula in LG. In the robotic arm, we identified three patients (3%) who died, one of them secondary to esophageal rupture at 85 days after primary resection.[4]

Conversion

Conversion was understood as an impossibility to perform the total laparoscopic approach, both technical difficulties or medical necessity. In 16 patients (8.3%) of LG and in 13 cases (12%) of RG the surgery was converted to an open procedure.

DISCUSSION

For many pancreatic disorders surgical resection offers the only chance for a cure, and surgery also plays a very important role in the symptom's palliation of unresectable pancreatics neoplasms.

Since the first laparoscopic staging for pancreatic cancer described by Dr Bernheim at the Johns Hopkins Hospital in 1911,[5] up to date, laparoscopic procedures for staging with laparoscopic intraoperative ultrasonography seem to be well accepted by the scientific community due to its higher sensitivity for identifying intraabdominal metastasis and facilitating biopsy and superior specificity for predicting unresectability, compared with CT scan.[6-8]

During the last 20 years many authors have reported large series of minimal access pancreatic surgery with multiple procedures, from distal pancreatectomies with or without splenic-preserving to pancreaticoduodenectomies (Whipple's procedure or even pylorus-preserving PD), including enucleations and central resections. In contrast to laparoscopic PD, laparoscopic distal pancreatectomies have been reported with increasing frequency. The main reasons are the easier surgical technique of the procedure without the need of an anastomosis and, of course, the well-known advantages of laparoscopy in general. But, minimal access PD is considered by many surgeons, most of them nonlaparoscopic surgeons, as an experimental procedure due to the associated morbidity and the very difficult surgical technique of this particular surgery.[9]

In the open approach, when the procedure is performed by significant expertise in pancreatic surgery, rates of morbidity and mortality are prone to decrease (morbidity = 18-54%; mortality = 1-4%). From the first description of the Whipple's procedure,[10] the technique has suffered some modifications and surgeons have to develope their surgical skills day by day until reach the morbidity and mortality rates of this era. Whenever the minimal access approach (laparoscopic and robotic) was between certain security limits, it must suffer a similar development as open approach.

Robotic surgery improves many of the shortcomings of laparoscopy. The dizzying development of the surgical industry, makes possible in robotic surgery binocular three-dimensional imaging, 360º movement of surgical instruments and a better comfort and precision, without the physiologic tremor, of the surgeon. These advances allow to perform complex procedures with nearly identical principles to open surgery making robotic surgery the probable expected step in minimal access pancreatic surgery.

Gagner et al[11] described the first laparoscopic pancreaticoduodenectomy in 1994 and reported a large series of 10 patients some years later[12] with a mean operative time of 510 minutes. From this series to the most recent ones, there is a significant decrease in the operating room time. Kendrick et al published in 2010[13] a series of 54 patients with a mean operative time of 368 minutes and state that their initially long operation time decreased from a mean of 7.7 hours in the first 10 patients to 5.3 hours in the last 10; on the other hand, Ammori et al[14] recently reported a small series of six patients with a mean operating room time of 628 minutes. Surprisingly, in RG, the WA was 394.77 minutes, practically the same as in LG (388.8 mins), in spite operative times usually remain significantly longer in robotic surgery than in other approaches.

Many publications report numerous potential benefits of robotic surgery over the traditional approach: Less pain, less risk of infection, less blood loss and transfusions, less scarring, faster recovery and quicker return to normal activities.[15,16] But, in this case, we found clear differences in mean estimated blood loss and mean hospital stay between both groups in favor of LG. The WA of the estimated blood loss was 178.7 ml for LG and 319.06 ml for RG. We can not explicate this difference and we would need a more thorough analysis to get conclusions. In the other hand the WA of the hospital stay was 9.9 days (LG) and 15.31 days (RG). This variations in the length of hospital stay can be explained by the differences in the health systems between Europe and North America as Giulanotti et al[4] expose in their article. The authors explain that the length of hospital stay of their series, divided in this article into two independent series according to the institution where the procedure was performed, varied depending if the patient was operated in Europe or in America. In the Italian group the mean hospital stay was 22 days and in the US group, was 9 days. They stress that Europeans patients do not go home if they have a drain in place but american patients were discharged at the 9th day (mean), with or without drain, to reduce the price of the procedure. We realized that this series is a large one which has a big influence in the final analysis, so we also suggest this as the main reason why the WA of the hospital stay is higher in RG than in LG.

Rates of periopertive morbidity in laparoscopic PD in series of high-volume range between 26 and 40%. In this review, we identified 69 morbidity cases (36%) in LG and 18 (21%) in RG, but these data are not very reliable because of two series of RG (60 patients; 55%) did not specifically report this variable. Although we did not take in count this cases for the final analysis we did not want to compare both groups due to the high difference in their sizes.

PPF is the most frequent and one of the most dangerous specific major complication after pancreatic resection. There is a huge variation between series in the reported rates, probably because of the different definitions of PPF used. In spite of the robotic surgery allows a better freedom of movement to perform an anastomosis, we found a higher percentage of fistula in RG (30%) than in LG (14.5%) when we compared both arms. Probably this finding could be caused because more than 50% of the patients of the Buchs et al publication[17] had pancreatic stump sclerosis, where small pancreatic leaks are common. The other article in which data showed a high incidence of pancreatic fistula was the Giulanotti et al publication.[4] They attribute this high incidence also to the subgroup of patient who followed injection sclerosis of the duct but do not rule out a surgical technique fail. However, similar rates of bleeding (RG: 9%; LG: 4%) and conversion (LG:8.3%; RG:12%) were found in both groups. Conversion rates was compared favorably with that in the literature (11.5%).

We can find similar rates of motality in high-volume centers for open PD (1 to 4%) and for minimal access PD (0 to 5%). We found five cases in the whole series of LG (2.7%) and three in the RG (3%) which is in keeping with the literature reviewed. In the article of Buchs et al,[17] there was one death as a result of a fatal cardiac arrhythmia in a patient over 70 years old. In spite of this death, the authors conclude that a totally robotic approach for PD can be performed safely in an elderly population, with similar results compared with younger patients. The other two cases reported by Giulanotti et al[4] were due to sepsis following

Boerhaave syndrome and from colonic ischemia at 85 days after primary resection and on day 20 respectively. These two last cases were not strictly secondary to the first surgery but to avoid personal opinions which could be a deciding factor in the comparison between the two groups, we decided to take them in count.

Hybrid approaches have been reported during the last years.[18-20] The initial approach is made by laparoscopy and the reconstruction with the anastomosis is performed with a surgical robot system. The outcomes are acceptable in safety and maintenance of the standard of care for the management of the disease process. In spite of a very few experience, (five patients in one series and 24 patients in other) this hybrid approach showed the feasibility of performing complex pancreatic resections and offers the possibility to improve along the learning curve with both approaches.

CONCLUSION

This is the first review in the literature which compares total laparoscopic PD with total robotic PD and can not demonstrate any clear differences between both in spite of the scant literature available. The use of robotics in this patient population is limited, making it difficult to get the possibility of prospective or randomized trials. However one might expect that the different groups would improve their outcomes once past the learning curve, and minimal access pancreatic surgery would clearly demonstrate its real face with regard to open approach.

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CASE REPORT

Laparoscopic Gonadectomy for Complete Androgen Insensitivity Syndrome

Lakkanna Suggaiah, Usharani Rathnam, Preetham Raj

ABSTRACT

Introduction: Androgen insensitivity syndrome is a form of male pseudohermaphrodite where the phenotype female has male gonads and is genotypically male.

Case report: We report a case of complete androgen insensitivity syndrome in a 22-year-old who underwent laparoscopic gonadectomy.

Discussion: Androgen insensitivity syndrome is the most common cause of male pseudohermaphroditism and third most common cause of primary amenorrhea.

Conclusion: Laparoscopy is an effective method in androgen insensitivity syndrome treatment, mainly due to the increased risk of malignant transformation of the testes. Psychosexual needs should be addressed along with low-dose hormonal therapy to maximize long-term success.

Keywords: Androgen insensitivity syndrome, Laparoscopic gonadectomy.

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INTRODUCTION

Androgen insensitivity syndrome (AIS) was previously called testicular feminization syndrome. Intersex is a rare X-linked recessive condition due to mutation at xq 11-q 12 localization on the androgen receptor gene. AIS is a form of male pseudohermaphrodite where the phenotype female has male gonads and is genotypically male. Importance of this syndrome is development of testicular tumor especially seminoma after puberty. The diagnosis is often based on absence of uterus, cervix, tubes and a vagina of variable length with nondysplastic testis.

CASE REPORT

A 22-year-old woman was admitted to ESIC Medical College PGIMSR, Rajajinagar, Bengaluru, with complaints of primary amenorrhea and infertility, referred to the surgical department by gynecology department for bilateral inguinal swelling. The patient was 175 cm tall, weighing 60 kg. External physical examination revealed well-developed breasts, abundant scalp hair with scanty pubic and axillary hair (Fig. 1). The vulva and perineum appeared normal and the vagina measured 5 cm in length, ending blindly. Family history revealed she was the only child with no similar complaints in the family. Transabdomino-pelvic ultrasound confirmed the absence of uterus and ovary and presence of bilateral masses of 3 × 2.5 cm in size, located near the internal ring of the inguinal canal. Imaging studies noted absence of prostrate and seminal vesicals.

Karyotype report was 46 XY (Fig. 2). Serum FSH was 10.7 μ/ml, serum estradial was 88 pg/ml, all other hormonal parameters and tumor markers were within normal limits.

After standard peroperative preparation, operative laparoscopy was performed under GA. Pelvic and abdominal inspection revealed absent uterus and ovaries. Bilateral gonads appearing as testis were attached near the internal ring of both inguinal canals. The pedicles of gonads were coagulated with bipolar cautery and cut with laparoscopic scissors to prevent the spillage of cells and contamination. The gonads were placed in endobags and removed intact after extending the port (Figs 3 and 4). There was no complication during the operation. The patient was discharged on the 3rd postoperative day after surgery.

Gross pathology reports mentioned the tissue marked as the right gonad measuring 3 × 5 × 2 cm with attached

Fig. 1: Thick long hair

duct and the left, 3 × 2 × 2 cm. Bilateral sertoli hyperplasia was noted on histology (Fig. 5).

In view of this, long-term conjugated estrogen 0.625 mg per day was started.

DISCUSSION

AIS is the most common cause of male pseudohermaphroditism and third most cause of primary amenorrhea.[2] It is also known as testicular feminization syndrome. Intersex male pseudohermaphroditism has an incidence of 1 in 20,000 to 64,000 male births.[1,2] John Morris (1953) described the anatomical, histological and clinical features based on 82 cases collected from over nearly 150 years of medical literatures.[3]

The typical mode of presentation is an adolescent female, who has breast development with the pubertal growth but has not attained menarche with absent or scanty pubic and axillary hair. Complete androgen insensitivity syndrome (CAIS)[4] may also be present in early infancy with bilateral inguinal or labial swellings. Bilateral inguinal hernias are rare in girls and it has been estimated that 1 to 2% of such cases have CAIS.[5] In review of literature, the case of CAIS in a 22 years female were the presence of testis, prostatic tissue, seminal vesicals which was confirmed by ultrasound of abdomen, hormonal analysis, operative findings and HPE.[6] Diagnosis of CAIS is usually with the absence of female internal genital organs on physical examination aided by pelvic ultrosonography, karyotyping, molecular genetic testing of the AR gene mutation (chromosomal locus xq 11q 12) and elevated testosterone LH level.[5] In our case,

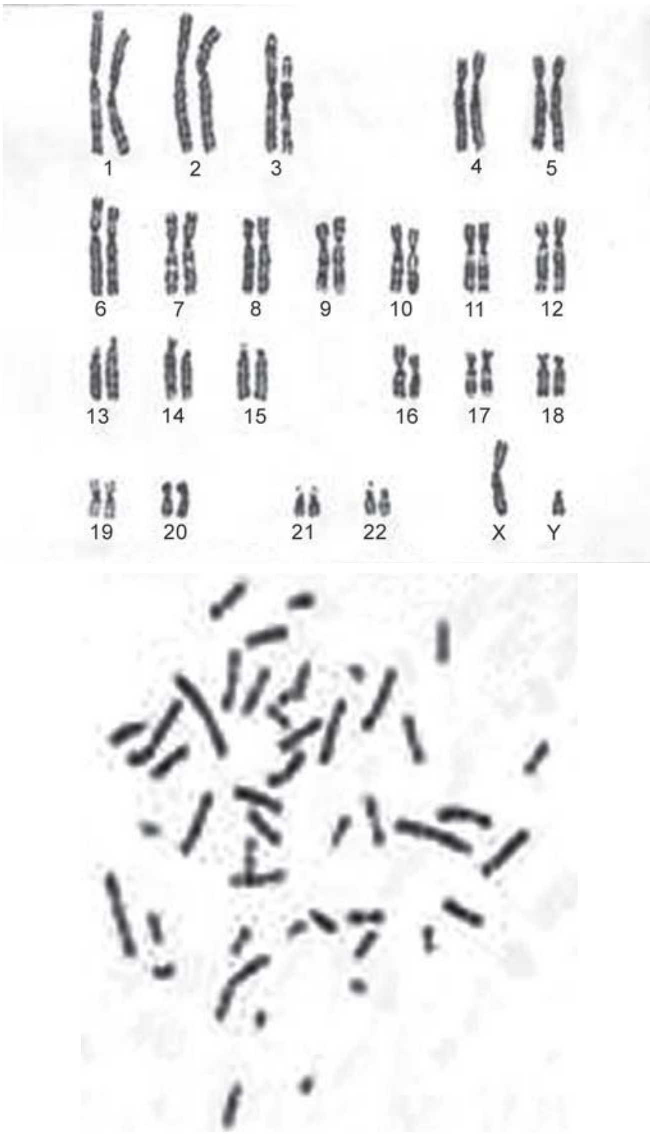

Fig. 2: Karyotype analysis—male karyotype-46XY

Fig. 3: Left gonad

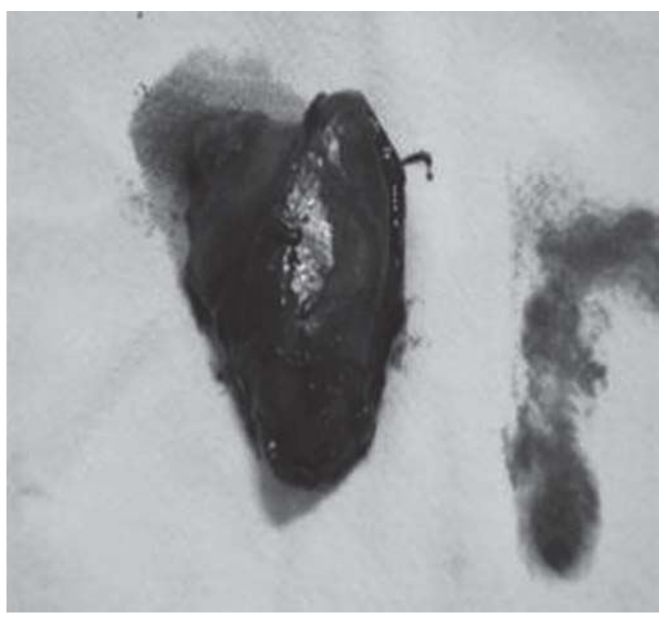

Fig. 4: Right gonad

Fig. 5: HPE-sertoli cell hyperplasia

Fig. 6: Laparoscopic gonadectomy

the diagnosis of CAIS was based on gynecological examination, laparoscopy and the karyotyping.

Partial androgen insensitivity syndrome (PAIS) is another category of intersex and is characterized by perineoscrotal hypospadiasis, micropenis and bifid scrotum. The testis may also be undescended. The most severe form of PAIS presents as isolated clitromegaly.[7]

Mild androgen insensitivity syndrome (MAIS) as a category of AIS was realized following investigation for male factor infertility which suggested defect in the androgen action leading to oligospermia with normal level of testosterone and increased life span.[7]

Gonadal tissue can be located in the inguinal canal or any where in the abdomen-sites that are invisible during laparoscopy. MRI has proven of value, for localization of nonpalpable undescended testis.[8] There is increased risk of dysgenetic gonads developing malignancy, which can be as high as 30%. In contrast to the other forms of gonadal dysgenesis, the incidence of tumors in AIS cases is rare before puberty and significantly higher after the age of 35 years.[6] Prophylactic gonadectomy is necessary in the postpuberty period to allow the development of the secondary sexual characters during puberty.[2,9] Laparoscopic removal of gonads has many advantages compared to laparotomy, foremost being minimal blood loss, rapid recovery, shorter hospital stay and minimum psychological trauma. Laparoscopy has better visualization of the entire abdomen and pelvis compared to laparotomy[10] (Fig. 6). Patients should be treated with long-term hormone replacement therapy (HRT) after gonadectomy.[1,2,11] Androgen supplementation is not useful because of insensitive androgen receptor.[12]

CONCLUSION

AIS should be suspected in cases with primary amenorrhea. Laparoscopic gonadectomy can be performed safely via a small caliber laparoscopy after puberty with long-term low dose hormone therapy because of the increased risk of malignant transformation of the testicles. Attention to psychological consideration in such patient is important to maximize long-term success.

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