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An analysis of the iatrogenic biliary injury after robotic cholecystectomy. Current data and future considerations

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Abstract. – OBJECTIVE: Minimally invasive techniques are the gold standard in surgery. Since conventional laparoscopic approach has been widely adopted, surgeons in their effort to further improve their skills passed to the era of the robotic assistance. The widespread adoption of robotics has led to the inevitable usage of robotic technology both in simple, as well as in more complicated procedures. Cholecystectomy is the "simple" surgical procedure to which every surgeon from the beginning of his career and besides specialization or subspecialization is exposed to, but the complications have a dramatic impact both for patient and doctor. The elimination of bile duct injury is crucial and robotics in the new era of surgery has to be the gold standard to a safe cholecystectomy.

MATERIALS AND METHODS: A comprehensive search of PubMed Database was conducted for English-language studies using the MeSH terms [Robotic cholecystectomy, bile duct injury]. We reviewed references of all reports for additional cases from 2000 to nowadays. We used the related articles link and searched the citations of reports in the ISI Science Citation Index to identify additional reports.

RESULTS: A total of 16 studies, including 2.264 patients that underwent robotic cholecystectomy were analyzed. Postoperative data and complications were collected from these studies. Bile duct injuries were more likely to be discovered during the first postoperative days as a bile leakage (8/2.264). One major bile duct injury was noticed, and most injuries were definitively treated at the hospital where the injury occurred with postoperative endoscopic retrograde cholangiopancreatography (ERCP) and stenting.

CONCLUSIONS: Robotic cholecystectomy is a safe and adequate alternative to conventional laparoscopic or open approach in term of safety. Furthermore, surgeons must be already experienced and familiar with robotic techniques, so as to overcome the problem of the bile duct injury.

Key Words:
Robotic, Cholecystectomy, Bile, Duct, Injury.

Introduction

Minimal invasive surgery for symptomatic cholelithiasis has been proved superior in postoperative outcomes compared with open surgery and is the gold standard for surgical treatment of gallbladder diseases[1,2]. Studies from all over the world suggest that robotic surgery can reduce postoperative pain and recovery time, reduce the need for postoperative analgesia and allow a more rapid return to normal activities[3]. Furthermore, it has been suggested that robotic surgery has several advantages when compared to standard laparoscopic surgery. Optics, ergonomics, a higher degree of precision in surgeon's hand, are all enhanced with the use of a robotic platform[4]. The application of robotics has eliminated many of the constraints experienced with conventional laparoscopic or open techniques, however challenge still remains[5]. Surgeons in the modern era have to eliminate the complications and cholecystectomy remains the ultimate challenge. As a matter of fact, a bile duct injury in a routine procedure can destroy the life of the patient or/and the surgeon's career.

The purpose of this study is to review all cases of robotic cholecystectomy in the English literature and analyze its feasibility and safety regarding the most dangerous complication which is bile duct injury. In addition, this study was designed

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to better understand the relationship of the usage of novel devices such as robotics for the identification and management of bile duct injuries.

Methodology

A comprehensive search of PubMed Database was conducted and the review covered a period from 2000 to 2017. The keywords used individually or in combination were: robotic cholecystectomy, bile duct injury.

Inclusion and Exclusion Criteria

Studies with data for robotic cholecystectomy were only assessed. These studies included technical notes, review articles, original articles, case reports studies, and case-matched comparison studies. Duplicate publications and those not written in English were excluded. For duplicate publications, the latest and most complete study was included. Laparoscopic procedures were excluded. The number of patients was not an exclusion criterion.

Results

Many studies have shown that iatrogenic bile duct injury can present after robotic cholecystectomy. Ayloo et al[6] in their study included 179 patients who underwent robotic cholecystectomy (RC) consisted of 30 males (16.7%) and 149 females (83.2%), with a mean age of 40.2 years with a mean BMI of 32.9 kg/m^2. Postoperative complications occurred in 6 patients (3.3%). Of these patients, two were readmitted to evaluate abdominal pain. One patient referred right upper-quadrant pain and the second had recurrent pancreatitis. Another patient had a pancreatic pseudocyst diagnosed preoperatively. This patient required endoscopic dilation of cystogastrostomy due to cyst infection. Another patient with bile leak was admitted for percutaneous drainage and endoscopic sphincterotomy, and one patient had to undergo postoperative ERCP to remove a common bile duct (CBD) stone. One patient required readmission for urinary retention and one patient was treated in the emergency room for postoperative pain.

Bibi et al[7] evaluated 102 patients undergoing Single Site Robotic Cholecystectomy (SSRC). The gender ratio was 2:1 (70% female *vs.* 30% males). The mean age was 51 year (18-87) and the mean BMI was 28.26. Elective cholecystectomy was performed in 69%. Patients who underwent cholecystectomy for acute cholecystitis comprised 31%. In this study, 4% of the patients developed postoperative complications. Postoperatively, two patients developed acute anemia. No evident cause of bleeding was diagnosed and no intervention of blood transfusion was required. These patients underwent diagnostic computed tomography (CT) scans and one also required magnetic resonance imaging (MRI) abdomen. Ileus and hospital-acquired pneumonia occurred in two patients. There were no intraoperative complications in any of the groups regarding any bile duct injury or bile spillage due to accidental opening of the gallbladder.

From October 2011 and July 2014, Balachandran et al[8] included patients who underwent single site robotic cholecystectomy or laparoscopic cholecystectomy for symptomatic gallbladder disease. One patient in the robotic group was seen at follow-up with postoperative bile leak and was successfully managed by ERCP and stenting.

Corcione et al[9] studied 32 elective cases who were scheduled to undergo robot-assisted laparoscopic surgery in their hospital from March 2002 to July 2003. There were 19 men and 13 women with ages ranging from 23 to 76 years. As it is reported in the study there was no bile duct injury. There was only a case of a patient with mild hemorrhage from the cystic artery; for this reason, the operation was converted to laparoscopic cholecystectomy due to dysfunction of the robotic system.

From February 2011 to December 2011, Buchs et al[10] performed 44 operations for symptomatic cholelithiasis. Among the 44 patients, 23 were included in an experimental protocol, using the indocyanine green (ICG) for an intraoperative fluorescent cholangiography (52.3%) and the rest (47.7%) underwent standard single site robotic cholecystectomy without ICG. There was no conversion but one intraoperative bleeding occurred in an obese patient in the ICG group, requiring an additional port for a bipolar forceps. Regarding postoperative complications, there was no difference between both groups. Two patients in the ICG group were evaluated for abdominal pain. They were successfully treated conservatively. One patient in the standard group was readmitted for an incisional hernia. None of the intraoperative or postoperative complications included bile duct injury.

From December 2004 to February 2006, Breitenstein et al[11] followed 50 elective robotic procedures and they report one postoperative bile leak from the cystic duct stump in the robotic group that was treated by endoscopic stenting of the common bile duct.

Braumann et al[12] evaluating 16 robotic cholecystectomies detected no major complication postoperatively and the patients had a monthly follow-up for 4 years.

Daskalaki et al[13] performed 212 robotic cholecystectomies with ICG fluorescent cholangiography in their center. They report 3 surgical complications that included 1 perihepatic hematoma and 2 readmissions for perihepatic abscess without evidence of bile leak. One of them was treated with placement of a drain under radiological guidance and one was treated conservatively.

Angus et al[1] performed 55 robotic cholecystectomies. Post-operative complications included two cases of urinary retention, one postoperative seroma in a trocar position, one postoperative ileus, two cases of right upper quadrant musculoskeletal pain, and one case of constipation. One patient was found to have retained common bile duct stones.

From 20 January 2012 to 4 May 2012, Buzad et al[14] performed 20 single site robotic cholecystectomies cases. Two patients had remnant stones in the common bile duct and were readmitted for postoperative ERCP. In one of these patients, the stones resulted in a bile leak that resolved with the ERCP.

Ayloo et al[6] reported 31 patients who underwent robotic single site cholecystectomy at a tertiary academic center by a single surgeon from February 2012 to February 2013. According to this report, two patients required placement of an additional 5-mm trocar for a suction catheter in the right mid abdomen. No cases required conversion to open or to traditional multiport technique. One patient had a superficial wound infection that was treated with a course of oral antibiotics and resolved without any further consequence. In the short-term follow-up, there were no bile duct or other injuries to the surrounding structures.

Chung et al[15] performed 70 single site robotic cholecystectomies (SSRC) from August 2013 to January 2015 for symptomatic gallbladder disease. There were two 30-day readmissions in the SSRC group, one for a retained stone requiring ERCP and biliary stenting and the other for a small hematoma that was conservatively treated. No bile duct injury was reported.

From June 2010 to May 2014, Baek et al[16] reported 925 patients who underwent robotic cholecystectomy on the bikini line. Surgical complications occurred in nine of the 925 patients (0.1%), including cystic duct leakage (n=4), bleeding (n=3), common bile duct injury (n=1), and bladder injury (n=1).

Bonder et al[17] reported the first series of robotic cholecystectomies from June to November 2001. There was one patient who suffered from solitary choledocholithiasis 29 months after robotic cholecystectomy. Abdominal sonogram, clinical examinations, and blood tests revealed no post-cholecystectomy-specific pathological findings. They report no bile duct injury in their study.

Pietrabissa et al[18] conducted a prospective observational study on 100 consecutive da Vinci single-site cholecystectomies. They mention two patients that underwent conversion to a laparoscopic procedure. No bile duct injury is referred.

Konstantinidis et al[19] performed robotic cholecystectomies in forty-five patients (22 women, 23 men) from March 2011 to July 2011. There

Table I. Studies including robotic single port cholecystectomy – Postoperative data.

Author	Year	No of patients	Morbidity %	Bile duct injury
Ayloo et al[6]	2014	179	3	1
Bibi et al[7]	2015	102	4	-
Balachandran et al[8]	2017	415	17.6	1
Corcione et al[9]	2005	32	3	-
Buchs et al[10]	2013	44	6	-
Breitenstein et al[11]	2008	50	2	1
Braumann et al[12]	2008	16	-	-
Daskalaki et al[13]	2014	212	2	-
Buzad et al[14]	2013	20	12	1
Ayloo et al[6]	2014	31	10	-
Chung et al[15]	2015	70	3	-
Baek et al[16]	2015	925	1.8	5
Bodner et al[17]	2005	23	0.1	-
Pietrabissa et al[18]	2012	100	4	-
Konstantinidis et al[19]	2012	45	12	-

were no conversions to either conventional laparoscopy or laparotomy. There were no major complications apart from a single case of postoperative hemorrhage. They report no bile duct injury.

Discussion

Robotic cholecystectomy has emerged as a novel technique that aims to reduce the postoperative pain and length of stay in hospital and in addition to increase manipulation of the surgeon and diminish the postoperative complications. Further advantages of robotic use include enhanced 3-dimensional view comparing to the two-dimensional view in laparoscopic resections, as well as the ease of handling different instruments. Development of single-site port robotic devices represents an evolution in medicine. Compared to the standard LESS procedure, the robotic single port may present several advantages such as increased dexterity, range of motion, ergonomics, and decreased instrument clashing. All these technical improvements have shortened the learning curve for these procedures. It is well known that the robotic arm hand unit has 7 degrees of freedom (DOF) that allows the hand to be precisely manipulated in a 3-dimensional space.

Another advantage of robotic over laparoscopic technique is the integration of a novel near infrared fluorescent vision system. That system enables the surgeon to acquire an intraoperative dynamic fluorescent cholangiography that could substitute the classic X-ray cholangiography and improve substantially the safety and efficacy of the procedure (2).

Despite the revolution in medical technology, bile duct injuries remain the most dreadful complication after cholecystectomy. Bile duct injuries are severe complications which may lead to bile leaks, strictures, recurrent cholangitis, peritonitis, secondary biliary cirrhosis, liver failure, and finally may result in death[20]. Even if properly repaired, these patients require life-long follow-up and their lives are affected from these complications.

This investigation shows that robotic cholecystectomy is associated with fewer and less severe bile duct injuries. Further, cholangiography performed during surgery increases the likelihood of intraoperative detection of bile duct injuries. This study did not attempt to explain whether the performance of cholangiography prevented bile duct injury, because it focused on the cases in which an injury occurred.

In addition, the size of each study was different from all others and also the surgeon's experience, so the probable error of recollection is noticed.

The results of this review show that only 9 bile duct injuries occurred and these injuries required only postoperative ERCP and stenting for treatment without biliary reconstruction to be referred. The small sample might be insufficient to draw conclusions, but given the nature of these injuries we believe that it is evident that robotic cholecystectomy can be proved a safe procedure. Nonetheless, it is likely that these data underestimate the magnitude of the problem, because studies with injuring bile ducts would be expected to be published less frequently than those free of such injury.

The introduction of robotics to general surgery provides a future perspective on how surgeons develop new skills and improve the new technology. With the acquisition of robotics even more precise surgery is possible, despite the expense of the procedure.

Conclusions

Robotics may facilitate the most widespread operation in surgery which is cholecystectomy, overcoming the laparoscopic and open surgery limitations. However, the available data still is not enough and limit the drawing of safe conclusions amongst surgeons. Further investigation is needed and that will be accomplished when a greater number of robotic cholecystectomies will be achieved.

Conflict of Interest

The Authors declare that they have no conflict of interest.

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