Abstract
The introduction of robotics has opened a new era in general and digestive surgery. Several advanced procedures are now performed with the robotic technique providing superior dexterity to surgeons while maintaining the profile of safety and benefits of minimally invasive surgery for patients. Pancreatic surgery, one of the last area of resistance to minimally invasive surgery, has not been spared by this surgical revolution. An increasing number of studies provided by high volume institutions have proven the safety and feasibility of robotics for pancreatic surgery. Pancreaticoduodenectomy, one of the most advanced surgical procedures in abdominal surgery, represents the most common type of pancreatic resection performed by robotic approach. The safety and feasibility is at present well demonstrated but its advantages over open and laparoscopic surgery and its long term oncologic outcomes are still to be proven in prospective studies.

This article reviewed the current experience of robotic pancreaticoduodenectomy reported in the international literature evaluating its safety, feasibility, short and long term outcomes.

The increasing number of reports dealing with this topic proven the growing interest of digestive surgeon for this approach which certainly will constitute the approach of choice for minimally invasive pancreatic surgery in the next future.

Keywords: Robotic surgery; Minimally invasive surgery; Pancreaticoduodenectomy; Pancreatic surgery; Pancreatocoitentric reconstruction; Short term outcomes

Introduction
Pancreatic surgery represents one of the most advanced fields in the areas of digestive surgery with an historically reported high rate of postoperative morbidity up to 50% [1].

Surgical approaches to the pancreatic gland require a detailed knowledge of the regional anatomy, dedicated surgical training and adequate skills to dissect tissues and vessels correctly and to perform digestive reconstruction. A large abdominal incision, which can significantly contribute to morbidity and compromise the postoperative immune response after pancreatic resection, is generally required to obtain adequate exposure of the pancreas [2].

In an effort to reduce the high historically rate of postoperative morbidity of pancreatic surgery; twenty years ago laparoscopic surgery was applied to the field of pancreatic surgery. Gagner et al. [3] described the first laparoscopic pancreaticoduodenectomy (PD). However since that time the development of pancreatic surgery has been slow compared with other field of pancreatic surgery. Reasons for that are multifactorial and include the technical challenges of open pancreatic surgery, the intrinsic technical limitations of laparoscopy, the fear of increased morbidity, oncologic concerns, and slow acceptance of laparoscopy among pancreatic surgeons [2].

PD, which represents one the most advanced procedure in the field of abdominal surgery, results very challenging to be performed laparoscopically due to the extensive dissection required around the superior mesenteric vessels and the complexity of digestive reconstruction. Even though some experienced surgeons reported a consistent experience in laparoscopic PD [4-6], the majority of pancreatic surgeons still perform this operation by traditional open surgery. Benefits of minimally invasive surgery have been proven for many digestive procedures and include improved cosmetic, reduced postoperative pain, reduced hospital stay and early recovery [7]. All this benefits of minimally invasive surgery might result of particular importance in case of oncologic diseases leading to an early delivery of adjuvant treatments. Very recently the use of robotic surgical system was introduced in the field of pancreatic surgery, providing a renewed interest for minimally invasive pancreatic surgery [8-13]. The aim of the current article is to review the current experience reported with robotic surgery for PD focusing on feasibility, safety, short and long term outcomes.

Material and Methods
Data collection
We searched the Medline (through PubMed) database electronically from 2003 up to and including April 2012. Search terms included the following: pancreas, pancreaticoduodenectomy, duodenopancreatectomy, Whipple’s procedure, robotic surgery, resection, and surgery. Terms were searched using both isolated and embedded approaches to identify published articles. Searches were limited to articles in English, those with abstracts and those covering human studies. There were no limits regarding the number of patients included in these studies. For each study, the following parameters were collected: author, period of inclusion, number of patients, Operating
the number of patients operated upon and the country in which the postoperative hospital stay ranged from 9 to 36 days and depended on PDs and Chalikonda et al. [24] reported 1 (3.3%) in 30 cases. However, in 44 consecutive cases, Zeh et al. [22] reported 4 (8.0%) in 50 robotic consistent. Buchs et al. [21] reported 3 (6.8%) of these complications arising from pseudoaneurysms reported in these robotic series was C) was very limited. Regarding the complications related to pancreatic after PD [8]. However, the rate of clinically significant fistula (Grade B, some studies that used sclerosis injection for the distal pancreatic stump achieved in the robotic group to the open group, Buchs et al. [21] found a longer operative time with the robotic approach (718 minutes vs 420 minutes; P=0.011). Moreover, they demonstrated a reduced blood loss (153 vs 0.210 ml; P=0.045) and a reduced length of bed stay and hospital stay (27.5 vs 96 hours; and 16.4 vs 24.3 days, respectively) in favour of the robotic group. Finally they reported a reduced complication rate associated with a robotic approach (25% vs 75%; P=0.05). Chalikonda et al. [24] in 2012 compared in a case–matched study, 30 consecutive robotic PDs to 30 well matched open cases. They reported comparable blood loss, morbidity, mortality, reoperation rate between the two groups, but a longer operative time (476.2 vs 366.4 min, P=0.0005) and a reduced length of hospital stay (P=0.043) in the robotic group.

Regarding the adequacy of oncologic resection in these studies, few authors have detailed the number of lymph nodes harvested. However, when reported, most of the studies showed the removal of more than 12 lymph nodes, which is considered the gold standard for open pancreaticoduodenectomy [2]. In addition, when comparing the results achieved in the robotic group to the open group, Buchs et al. [21] found an average of 16.8 lymph nodes harvested after a robotic approach and 11 after an open approach (P=0.02).Similarly only a few studies have reported the rate of positive margins for robotic PD. This rate varied from 0 to 11%, and in all cases the positive margin involved was the retroperitoneal margin, with no involvement at the pancreatic or biliary margins. However, only one study reported the use of a standardized pathological protocol for the assessment of the retroperitoneal margin which is nowadays considered the gold standard in case of pancreatic adenocarcinoma [22].

Finally, considering oncological safety, Giulianotti et al. [8] reported their follow up for malignant lesions. Among 26 patients with adenocarcinoma, 9 were alive with no recurrence at a mean follow up of 16.8 months (range: 8-47). Three were alive with recurrence (local,
haptic and pulmonary recurrences). And finally, 5 patients died due to recurrence (after 20, 11, 11, 9 and 7 months). Among the group with ampullary cancer (15 patients), 10 are alive and disease free at a mean follow up of 50.5 months (range: 8-91). Three patients died, of whom one from recurrence. Of note, no port-site metastases were reported. Kendrick et al. [5] reported 31 patients operated on for pancreatic adenocarcinoma. The mean follow-up for these patients was 7.4 months, with 6 dying as a result of disease recurrence and no port site metastasis were observed.

Discussion

Pancreatic surgeries have challenged for twenty years the field of minimally invasive surgery. Since the first description by Gagner et al. [3] in 1994 of a laparoscopic PD, several groups attempted to perform this complex operation by laparoscopic approach. Even though some study provided by highly skilled laparoscopic surgeons demonstrated the feasibility of laparoscopy for PD, recently less than 300 cases performed were identified by three different review studies [2,27,28].

Reasons for that are related to the inherent complexity of this operation which entails an extensive dissection around the superior mesenteric vessels followed by a complex reconstruction. These tasks are difficult to be performed laparoscopically due to the limited range of motion of laparoscopic instruments, the two dimensional view and to the steep learning curve.

The introduction of robotic surgery might challenge this concept and might increase the feasibility of a minimally invasive approach for PD.

Robotics seems to improve some steps of this procedure, such as lymphadenectomy and uncinate process dissection, thereby improving the quality of the resection [8]. The microsurgical ability provided by the robotic surgical system also confers superior dexterity when performing biliary and pancreatic reconstruction [5,8,14]. Finally the use of robotic systems extends the indications for minimally invasive pancreaticoduodenectomy to more complex cases including vascular reconstructions [11].

Over the last three years more than 200 cases were reported by different groups, mainly US centres, with outcomes comparable to open surgery. The largest experience was provided by the University of Illinois at Chicago group [8], who pioneered the use of robotic group for several complex robotic pancreatic surgeries including vascular resection with reconstruction. The feasibility of robotic PD remains well demonstrated with some groups reporting a noteworthy 0% conversion rate. When present, conversion was most consistently due to technical difficulty or bleeding with one reported death related to this complication. The rate of conversion decreased with the increasing experience of the team and all conversion were identified by three different review studies [2,27,28].

This can attenuate the hypothesis of a decreased morbidity rate for robotic PD. The need of having two experienced surgeons (console and patient side surgeons) performing the case.

In conclusion, the robotic approach for PD represents a safe and valid alternative to the open approach in selected cases for well experienced pancreatic surgeon. This approach might provide to patients all the benefits of minimally invasive surgery but not decrease the rate of pancreatic related complications. The long term follow up in case of malignant disease remains to be determined in large prospective studies.

References


