Outcomes of hepatopancreatic robotic surgery: Update from the literature - Hepatic surgery

E Ortiz-Oshiro¹,², B Lasses-Martinez¹,², J Dziakova¹,²

Abstract
Introduction
The first reports on Da Vinci system application for hepatic and pancreatic procedures appeared in 2003. Ten years after, several teams from all around the world have incorporated these procedures for a variety of indications. This review tried to analyse the outcomes reported in the literature on hepatopancreatic robotic surgery, to find out the current trend of the most experienced groups. This is the second part, where robotic hepatic surgery was evaluated. We have identified in the literature nine case series and six comparative studies on robotically assisted hepatic surgery. Also, several reviews have been published from 2011, one systematic review in 2013 and two more reviews on major robotic hepatectomies very recently.

Discussion
Some technical steps of the procedures, as parenchymal transection, hilar and hepatocaval dissection or ligature control of major vessels, have shown to enhance through robotic assistance. Feasibility and safety of robotic liver surgery have been demonstrated, but no clinical advantages in intraoperative or postoperative outcomes have been exposed respecting to its laparoscopic and open counterparts. Otherwise, oncological long-term results remain poorly cleared.

Conclusion
Robotic approach seems to enlarge the number of patients candidate to benefit from minimally invasive surgery. Nevertheless, further randomized and controlled studies are needed to support the growth of robotic hepatic surgery.

Introduction
PC Giulianotti and his team published the outcomes of the first cases of laparoscopic hepatic surgery assisted by robot in 2003³. Since then, many groups have reported their experience and results. Most of the literature is based on case series or case reports. There are some comparative studies and systematic reviews.

The largest published experience at the moment is Giulianotti PC et al with 70 patients². Intraoperative and short term outcomes of around 220 patients have been reported. Almost every kind of hepatic resection has been performed by laparoscopy with robotic assistance. It has been applied for the treatment of benign disease such as haemangiomas, adenomas, cystic lesions, schwannomas and hepatolithiasis³. A case of robot-assisted right lobe donor hepatectomy was published in 2012⁴.

The treatment of malignant lesions is also possible. It has been demonstrated that robotic approach respects the oncologic principles of open surgery: negative margins, no direct manipulation of the tumour, anatomic resections and minimum blood loss⁵. Resections of hepatocarcinoma, hepatic metastasis, cholangiocarcinoma and hepatoblastoma have been reported.⁶

We have identified in the literature nine case series and six comparative studies on laparoscopic hepatic surgery robotically assisted, one of them publishing outcomes of two series (hepatocellular carcinoma and colorectal liver metastases)⁶. We will review the published results of all these teams. They are shown at table 1 (Case series hepatectomy, arranged according to number of cases)²,⁵,⁷,⁸,⁹,¹⁰,¹¹,¹²,¹³ and table 2 (Comparative studies, same arrangement)⁶,¹⁴,¹⁵,¹⁶,¹⁷,¹⁸.

Intraoperative outcomes
Operative times ranging from 61.4 ± 26.7 minutes¹² to 507 (120-812) minutes⁵ have been reported. Major hepatectomies need longer operative times⁹,¹¹. Robotic approach uses to take a longer operative time when compared to open and laparoscopic surgery¹⁴,¹⁶.

Nevertheless, differences in operative time between robotic and laparoscopic surgery have been found as not statistically significant by some groups⁵,¹⁵,¹⁷,¹⁸. Others do not report p value⁶,¹⁶.

Blood loss rates were widely variable, ranging from 50 (5-1000) ml⁸ to 457 (100-2000) ml⁹. This difference is mainly related to resection type (minor or major hepatectomies)⁵. In comparative studies, blood loss has been greater with robotic surgery when compared with laparoscopic approach in some cases¹⁴,¹⁵, and the opposite in other reports⁵,¹⁶,¹⁸.

Conversion to hand port assistance or open surgery rate goes from 0,11,12,13 to 8.6%¹⁰. Comparative studies report less conversion rate with robotic surgery when compared with laparoscopy¹⁴,¹⁵, but differences are not always statistically significant. Conversions occurred mainly because of bleeding, uncertain tumour margin, difficulty in liver mobilization or hilar dissection and technical limitations⁵,¹⁹.

Postoperative outcomes
It is well-known that length of stay (LOS) is very dependent on the health systems management of the different countries. This fact delivers great variability in the LOS reports: from 2 ± 0.4 days¹² to 11.7 (5-46) days⁵.

Comparative studies show scarce non-significant differences in LOS between robotic and laparoscopic surgery. Nevertheless, further cases are needed to support the growth of robotic hepatic surgery.

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Robotic hepatectomy is considered to be safe and feasible if the team has advanced laparoscopic and liver surgery skills. The short-term results are similar to open or laparoscopic surgery and long-term oncological outcomes are not clear. From a technical point of view, some advantages have been described for robotic liver resection. PC Giulianotti et al. reported great improvement in two phases of the procedure: the hilum and the hepatocaval dissection. On the other hand, overall survival was not reported in any of the studies. The longest mean follow-up time were 36 months in patients with colorectal metastases and 25.1 months in a group of 19 patients diagnosed with malignancy.

### Table 1: Case series hepatectomy.

<table>
<thead>
<tr>
<th>Author/ Year</th>
<th>N</th>
<th>Malignant</th>
<th>Major hepatectomy</th>
<th>Intraoperative outcomes</th>
<th>Operative time (min)</th>
<th>Blood loss (ml)</th>
<th>Conversion to open</th>
<th>Length of hospital stay (days)</th>
<th>Morbidity</th>
<th>Biliary leak</th>
<th>Positive margins</th>
<th>30 day Mortality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Giulianiotti PC 2011 (2)</td>
<td>70</td>
<td>60%</td>
<td>38.5%</td>
<td></td>
<td>270 (90-660)*</td>
<td>262 (20-2000)*</td>
<td>5.7%</td>
<td>7 (2-26)*</td>
<td>21.4%</td>
<td>2.8%</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Lai ECH 2013 (7)</td>
<td>42</td>
<td>100%</td>
<td>NM</td>
<td>229.4 ±82.8**</td>
<td>412.6 (10-350)**</td>
<td>4.8%</td>
<td>6.2 ±36**</td>
<td>7.1%</td>
<td>4.7%</td>
<td>7%</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Choi GH 2012 (5)</td>
<td>30</td>
<td>70%</td>
<td>66.6%</td>
<td>357 (120-812)**</td>
<td>343 (95-1500)**</td>
<td>6.6%</td>
<td>11.7 ±20**</td>
<td>43.3%</td>
<td>6.6%</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Chan OC 2011 (8)</td>
<td>27</td>
<td>77.7%</td>
<td>3.7%</td>
<td>200 (90-307)*</td>
<td>50 (5-1000)*</td>
<td>0</td>
<td>5.5 ±11*</td>
<td>7.4%</td>
<td>3.7%</td>
<td>NM</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Giulianiotti PC 2011 (9)</td>
<td>24</td>
<td>70.8%</td>
<td>100%</td>
<td>337 (240-480)**</td>
<td>457 (1000-2000)**</td>
<td>4.1%</td>
<td>9 ±23**</td>
<td>25%</td>
<td>4.1%</td>
<td>4.1%</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Casciola L 2011 (10)</td>
<td>23</td>
<td>82.6%</td>
<td>0%</td>
<td>280 (150-420)**</td>
<td>245 (0-1000)**</td>
<td>8.6%</td>
<td>8.9 ±36**</td>
<td>39.1%</td>
<td>4.3%</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Lai ECH 2012 (11)</td>
<td>10</td>
<td>90%</td>
<td>100%</td>
<td>347.4 ±85.9**</td>
<td>407 (1000-600)*</td>
<td>0</td>
<td>6.7 ±35**</td>
<td>30%</td>
<td>20%</td>
<td>30%</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Kandil E 2013 (12)</td>
<td>7 (2 SP)</td>
<td>42%</td>
<td>142%</td>
<td>61.4 ±26.7**</td>
<td>100.7 (10-200)**</td>
<td>0</td>
<td>2 ±0.4**</td>
<td>14.2</td>
<td>0</td>
<td>NM</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Patrini A 2009 (13)</td>
<td>7</td>
<td>100%</td>
<td>0%</td>
<td>NM</td>
<td>NM</td>
<td>0</td>
<td>10 ±7*</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

*median (range) - **mean (SD/range), SP: single port, NM: not mentioned, SP: single port, NM: not mentioned.

Considerations on pathology

There is still scarce information on the morbidity and mortality of major hepatectomies, which is of paramount importance in the surgical management of colorectal metastases. In respect to bleeding control, a very difficult aspect of laparoscopic approach, robotic hepatectomy has not shown higher incidence of biliary leaks.

Other considerations: One study reports 7.6% in robotic group vs 0 in laparoscopic group vs 0 in open group (no p value reported), and Lai ECH 16.6% in robotic group vs 0 in hand-assisted laparoscopic group and 0 in laparoscopic group (no p value reported).

of minimally invasive major hepatectomies, robotic approach is considered to facilitate the procedure by preventing major blood loss as compared with a purely laparoscopic technique, due to the increased degrees of freedom in the instruments and 3-D vision. Thus allowing vessel control with suture ligation rather than stapling, to avoid the difficulties of staple placement. Some groups do not perform Pringle manoeuvre, while others consider that robot-assisted liver surgery can be made safer by the use of the extracorporeal Pringle manoeuvre. Otherwise, two cases of robotic-assisted single-port access liver resection have been recently reported.

Only two studies in this review include cost analysis. One of them is a Chinese comparison between robotic, laparoscopic and open hepatectomies published in 2011. Hospital costs were superior for the robotic procedures (12,046 USD vs 7,618 USD vs 10,548 USD), due to the expensive robotic instruments and the longer operative times, according to authors. The other study comes from Pittsburgh University, PA, USA, published in 2012, comparing robotic versus laparoscopic approach. This group analyses direct cost of operating room supplies and describes no significant differences between robotic and laparoscopic hepatectomies, but for clips cost (16 USD in the robotic group vs 65 USD in the laparoscopic group, p=0.022). Nevertheless, they recognise the economic impact is substantially greater when considering the indirect costs of installation and maintenance of the robotic system.

Discussion

Although it seems to exist unanimous agreement on feasibility and safety of robotic liver surgery, heterogeneity in many issues of the published studies (diagnosis, type of resection, techniques...) makes very difficult to evaluate results and to arrive to valid conclusions.

In fact, there are no metaanalysis as far as we know at the moment. We have identified several reviews, the first of them published in 2011, two more in 2013, one systematic review and two more reviews on major robotic hepatectomies. In 2011 review, their authors stated that "through implementation of robotic assistance, complex hepatobiliary surgeries can potentially be performed by surgeons who otherwise have fundamentally strong minimally invasive experience but may not have the acquired level of expertise derived from a cumulative high number of complex cases" and this could result in "more liver resections performed with a minimally invasive approach and more data to compare the true clinical benefits of robotics in liver surgery." Three years later, worldwide experience in robotic hepatectomy has not enlarged so much. The cost of the robotic equipment may probably account for the principal reason.

Through robotic assistance, the well-known advantages of minimally invasive liver surgery are expected to be able to encompass a larger number of patients. Some technical factors may contribute to such goal: stability and full exposure of the plane during parenchymal transection, improvement of hilar and hepatocaval dissection, 3-D visualization, wristed instrumentation for simple ligature control of major vessels instead of staplers... Nevertheless, some specific drawbacks have also been described for robotic hepatectomy: need for two well-trained surgeons in the operating room, lack of tactile feedback. Respecting to training, it is possible that the learning curve for robotic hepatic resections may be shorter than that of conventional laparoscopic liver surgery. In spite of that, there is a lack of structured training programs for future robotic surgeons.

A systematic review published in 2013 included nineteen series and 217 patients, with wedge resection and segmentectomy as most commonly performed procedures. Conversion rate was 4.6% and complication rate 20.3%. Although long-term oncologic outcomes were not analysed, short-term perioperative results seemed comparable to those of conventional laparoscopic liver resection.

Major hepatectomy (defined as the resection of three or more liver segments) remains one of the last frontiers of laparoscopy because of its technical challenges: controlling haemorrhage from major vessels, avoiding gas embolism, limiting postoperative complications and ensuring margin-free tumour resection. Minimally invasive liver resection surgery requires expertise in open hepatic resection surgery, minimally invasive surgery and laparoscopic ultrasonography.

Robotic assistance may provide technical advantages that could translate into clinical benefits and expansion of minimally invasive approach to complex hepatobiliary procedures. Nevertheless, the current state of robot-assisted hepatectomy remains limited, and experience is also limited and confined to just a few institutions.

Conclusion

Robotic-assisted liver resection appears to be comparable to its laparoscopic and open counterparts in terms of intraoperative and short-term outcomes. Otherwise long-term results have not been well defined at the moment. Further randomized and controlled studies are needed to answer these important questions.

References