Laparoscopic *vs.* robotic surgery: What is the data?

Epameinondas Dogeas^, David A. Geller

Division of Hepatobiliary and Pancreatic Surgery, Department of Surgery, University of Pittsburgh Medical Center, Pittsburgh, PA, USA

Correspondence to: David A. Geller, MD. UPMC Montefiore, 7 South, 3459 Fifth Ave., Pittsburgh, PA 15213-2582, USA. Email: gellerda@upmc.edu.

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Laparoscopic liver surgery (LLS) is rapidly expanding including laparoscopic major hepatectomy (1), and studies have demonstrated that LLS has several important peri-operative clinical benefits over open hepatectomy including less blood loss, less narcotic requirement, fewer complications, and reduced hospital stay (2,3). Furthermore, three randomized clinical trials have shown that LLS performed for primary or secondary hepatic malignancies does not compromise oncologic outcomes compared again to open hepatectomy (4-6).

Robotic liver surgery (RLS) was first reported in 2003 and has since been regarded as the next step in the evolution of minimally-invasive hepatectomy (7). The robotic surgery platforms have several inherent technical features that are appealing to the hepatic surgeon. These features include articulating instruments with more degrees of freedom than conventional laparoscopic instruments, tremor filtering, a surgical endoscope with 3D and magnified view that is controlled by the surgeon and improved comfort and ergonomics for the console surgeon. These combined features lead to less reliance on the assistant surgeon and allow the operating surgeon to perform complex maneuvers such as intracorporeal suturing and vessel dissection with more ease. Theoretical disadvantages of RLS include the lack of haptic feedback, longer operating time due to the required additional steps to "dock" and "undock" the robotic platform and higher costs compared to LLS. Indeed, Tsung *et al.* in a matched comparison of 57 robotic liver resections with 114 laparoscopic cases, reported similar peri-operative outcomes, but a significantly longer median operative time for RLS (253 *vs.* 199 minutes) (8). The 2018 International consensus statement on robotic hepatectomy surgery summarizes the recent literature on RLS and concludes that it is a safe and feasible as traditional open hepatectomy, but it is associated with longer operating times, less intraoperative blood loss, shorter length of stay and fewer complications when compared to open liver surgery (7).

In terms of minimally-invasive major hepatectomy, both laparoscopic and robotic approaches appear to have equivalent peri-/postoperative outcomes when performed in select patients and high-volume centers according to a recent meta-analysis by Ziogas *et al.*, which included seven studies with a total of 300 laparoscopic and 225 robotic major hepatectomies (9). However, other smaller studies have suggested that RLS is associated with higher intraoperative blood loss and longer operative time compared to LLS (10,11). In terms of long-term oncologic outcomes, a recent propensity-matched analysis of patients who underwent LLS (n=514) or RLS (n=115) for colorectal cancer liver metastasis reported equivalent 5-year overall-survival (OS) and disease-free survival (DFS) between the two groups (12). Regarding cost, LLS has been shown to be cost-effective compared to open hepatectomy with 17% lower total costs on average (13). When comparing cost between LLS and RLS, several studies have shown higher costs associated with the use of the robotic platform (14). In a large meta-analysis of 38 studies, that included 1,674 patients who underwent LLS and 390 patients with RLS, Ziogas *et al.* showed higher operating room costs,

^ ORCID: 0000-0001-9751-534X.

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hospitalization costs, and total costs for RLS compared to LLS (15).

In the recent study by Croner *et al*., the authors report on peri-operative and clinical outcomes of RLS versus LLS of 29 original studies on minimally-invasive liver surgery identified through PubMed query (16). A total of 1,392 patients who underwent RLS and 1,965 patients who underwent LLS were included in their analysis. Baseline patient characteristics in terms of age, Body Mass Index and mean tumor size were similar between the two groups. The authors report similar estimated blood loss (RLS: 30–500 *vs*. LLS: 30–513 mL) and similar rates of peri-operative transfusion (RLS: 0–25.0% *vs*. LLS: 0–23.1%) in the two cohorts. The mean operative time appeared to be somewhat shorter in the RLS group (121–425 versus 130–565 min for LLS). Similarly, the rate of conversion to an open approach appeared to be slightly decreased for RLS patients (0–20.0% versus 0–30.9% for LLS). Perioperative morbidity and mortality were found to be higher for RLS (0–68.0% versus 0–35.3% and 0–10.0% versus 0–5.0% respectively). The authors also found a trend towards lower rate of microscopic margin involvement by tumor (R1 resection) with the use of RLS (0–11.1% versus 0–23.1% in LLS). Data about costs was captured in five out of the twenty-nine studies included in the analysis. All five reported significantly higher costs associated with RLS compared to LLS. Furthermore, three studies reported long-term oncologic outcomes following minimally-invasive hepatectomy for cancer and all three report no difference in OS and DFS between RLS and LLS. Finally, the authors report on their own institutional experience with minimally invasive left lateral sectionectomy which consisted of 22 patients (13 patients with RLS and 9 with LLS). The robotic approach was associated with a significantly longer operative time of 243 min compared to 160 min in the LLS group (P=0.01), while no differences in other peri-operative outcomes were discovered.

In summary, LLS is associated with significant peri-operative benefits and lower costs compared to open liver surgery, without compromising oncologic outcomes. Similarly, RLS appears to also be a safe alternative to open liver resection with short-term clinical benefits. However, when comparing LLS to RLS, peri-operative and long-term outcomes appear to be equivalent, while the cost of RLS is higher compared to laparoscopy. The present study by Croner *et al*. confirm the above findings and agree with the prior literature. Further research is required to identify if there is a subset of patients where the higher cost and longer operative time of RLS is offset by clinical benefits.

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