Commentary

Robotic pancreaticoduodenectomy after the learning curve—a new hope

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First, we would like to congratulate Liu *et al.* for their successful multicenter study including 1,032 patients undergoing robotic pancreaticoduodenectomy (RPD) and 1,154 open pancreaticoduodenectomy (OPD) in seven high volume centers in China over an 8 year period (1).

To ensure the best possible outcomes of both techniques, RPD was performed by five surgeons from three centers after overcoming the individual learning curve that was defined as having performed >40 RPD. On the other hand, OPD was performed by 9 surgeons from 6 centers after reaching the individual learning curve, defined as an experience of >60 OPD.

Interestingly, after the above defined learning curve, the authors found no significant differences in relevant postoperative outcomes such as pancreas specific complications (clinically relevant pancreatic fistula, delayed gastric emptying, postpancreatectomy hemorrhage), reoperation rate and 90-day mortality. Only advantages for RPD were a slightly reduced blood loss and reduced length of stay by two days (12 *vs.* 14 days).

Remarkably, Liu *et al.* based their learning curve definition on their own published data of 100 cases undergoing RPD. To define the learning curve a cumulative sum (CUSUM) analysis of the operation time was performed, showing two learning curve phases after 40 and 60 patients (2). With this rigorous learning curve assessment, Liu *et al.* ensured, that the present study compared the post learning curve results of experienced surgeons for both OPD and RPD only.

While a generally accepted definition or assessment of "*the learning curve*" in pancreatic surgery is missing (3), a recent systematic review showed high variability in intra- and postoperative parameters used to define learning curves, the number of parameters used for the analysis and type of analysis used (statistical *vs.* arbitrary split groups) (4). In addition, not only the individual surgeon, but the institution as a whole has a specific learning curve, meaning that all other disciplines, anesthesia, intensive care, interventional radiology, endoscopy, nursing staff etc. contribute to changing results when accumulating experience. The systematic review by Müller *et al.* suggest that the assessment of the learning curve should ideally be based on (I) an adequate statistical calculation, (II) analyze both intraoperative- and postoperative parameters, and (III) should furthermore consider both individual surgeon- and institutional learning curves (4).

It is suggested that robotic systems can compensate for some downsides of laparoscopic PD (LPD). Especially, the transition from OPD to the minimally invasive approach seems to be easier for RPD than LPD. The role of LPD *vs.* OPD has been evaluated in a recent meta-analysis of three randomized controlled trials (RCTs)' comparing OPD with LPD (5). Nickel *et al.* found no significant differences for perioperative outcomes including pancreas-specific complications as well as 90-day mortality. While the study found no advantage for LPD, a high risk of bias and moderate to very low certainty of evidence has to be taken into account when interpreting the results. In addition, one of the three RCTs had to be terminated early due to safety

concerns in the LPD group, possibly related to learning curves (5). The currently largest RCT from 14 Chinese centers included 656 patients randomized to either OPD or LPD and was published in 2021 with the primary endpoint length of stay. All participating surgeons had a minimal experience of at least 104 performed LPD, resulting in a reduced length of stay of 15 *vs.* 16 days. However, the postoperative complication-, reoperation- and mortality-rates were all similar (6). This very nicely performed study again confirmed that there are no clinically relevant advantages of the laparoscopic over the open technique. Furthermore, the marginal benefits of LPD should be carefully balanced against the extensive learning curve and safety concerns of the procedure (7,8).

The evidence map of pancreatic surgery (www.evidencemap.surgery) shows eleven ongoing studies comparing minimally invasive [RPD (n=4), LPD (n=6), RPD and LPD (n=1)] *vs.* OPD at the moment (9). Evidence for LPD *vs.* RPD is even more limited coming from non-randomized cohort studies only (10). In the systematic review by Kamarajah *et al.* (10) RPD was associated with lower conversion and transfusion rates than LPD, however postoperative complications and R0 resections were not statistically different. Currently, there is one ongoing RCT comparing LPD and RPD (ChiCTR1900024490) (9).

While studies on minimally invasive PD often focus on short term outcomes, the present study by Liu *et al.* moreover evaluated the subgroup of patients with pancreatic ductal adenocarcinoma (PDAC) and found no differences for disease-free survival and median overall survival (1). Interestingly, during the learning curve key factors of surgical quality seem to improve at different time points after introduction of a novel procedure. We therefore proposed a three phase model to report the learning curve in pancreatic surgery with the phases competency, proficiency, and mastery (4). In a first phase, competency is shown by improved intraoperative parameters such as blood loss and OR time, in a second phase improved postoperative outcomes demonstrate proficiency and after that, in a third phase oncologic outcomes reach benchmark values (mastery). Therefore, we would like to highlight the importance to not only focus on short-term perioperative outcomes, but to demonstrate equality or superiority of RPD *vs.* LPD and OPD in term of pancreas-specific complications, overall- and disease-free survival, demonstrating the high value of the study by Liu *et al.* Therefore, it is now important to compare RDP and OPD in a randomized manner after the learning curve to gain a high level of evidence. The EUROPA trial (EvalUation of RObotic partial PAncreatoduodenectomy) from Heidelberg compares RPD *vs.* OPD in a randomized fashion with overall postoperative morbidity as primary endpoint (DRKS00020407). Another of the twelve RCTs on this topic is currently conducted by the same study group from China (ChiCTR2000038932). The results of these RCTs are eagerly awaited and give new hope for improved outcomes after PD.

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