Laparoscopic adrenalectomy by transabdominal lateral approach: can preoperative risk factors predict complications?

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During the last decade, laparoscopic adrenalectomy (LA) largely replaced open adrenalectomy (OA) as the preferred approach for most adrenal lesions due to greater surgeon experience with advanced laparoscopy, improved technology, and better short-term patient outcomes (1). Published literature suggests that experienced surgeons perform LA for a wider range of indications than in years past (2-4). Indications for LA continue to change as surgeons gain greater experience with minimally invasive techniques (including use of the robotic surgical platform); more adrenal lesions are identified by high-definition imaging, and increasingly larger benign and indeterminate adrenal lesions are selected for LA (2-5).

Studies support the clinical benefits of LA compared to OA including shorter operative time, lower transfusion requirement, less pain, shorter hospital length of stay (LOS), and lower 30-day morbidity (2-4,6,7). Fewer reports characterize preoperative risk factors that potentially influence outcomes and might aid in selecting patients for LA. A recent single-center, retrospective cohort study of 402 patients investigated the preoperative risk factors that may influence the choice of operative approach to adrenalectomy (1). Patients who underwent LA (343 transabdominal, 13 retroperitoneal) were compared to those initially selected for OA (n=46). The two cohorts were similar with respect to gender, body mass index (BMI), lesion location, history of multiple endocrine neoplasia, and history of prior abdominal operation. Perhaps not surprisingly, the cohorts differed by age, surgical risk, tumor size, malignancy status, and adrenal lesion functionality. The authors found that adrenal tumor size and need for concurrent procedures were the preoperative risk factors most likely to impact selection of patients for OA. These two risk factors—tumor size and concurrent procedures—also increased the likelihood of conversion to OA and 30-day morbidity (1). This study highlights that broadening the potential indications for LA is not without risk even in experienced hands. Specifically, radiographic tumor size greater than 8 cm increased the odds of conversion to OA but tumors up to 6 cm did not, likely due to the experience of the operating surgeons. The authors also note that the need for and type of concomitant procedures (such as multi-organ resection, enterolysis, liver biopsy, etc.) performed during adrenalectomy should serve as a surrogate for disease severity and case complexity (1). This preoperative risk factor may be a good indicator of a complex clinical scenario that warrants a surgeon with significant experience in both LA and OA.

More recent evidence explores the concept that patients with larger adrenal lesions portend a greater risk of complications so may benefit from undergoing adrenalectomy by significantly experienced surgeons. Coste *et al.* conducted a single-center, retrospective study of all patients who underwent LA by transabdominal approach from 1994 through 2013 (8,9). The operating surgeons were grouped according to operative experience, and cases were followed for complications. Specifically, junior surgeons were those who performed 30 or fewer adrenalectomies

while senior surgeons completed greater than 30 adrenalectomies. The operating surgeons' outcomes were assessed over time to define the impact of experience on rate and severity of perioperative complications. Complications were graded by Clavien-Dindo classification (grade ≥2 only) and further classified as surgical or medical in nature. Specifically, surgical complications were considered directly attributable to the operation, while medical complications comprised all other negative outcomes. In total, 520 patients underwent LA via transabdominal approach. Patients had a median age of 49.6 years, BMI of 27.5 kg/m^2, and most were female (57.7%). Fewer had a prior abdominal operation (45.2%) or genetic disease (7.1%). Conn's syndrome was the most common indication for operation (35.2%) followed by pheochromocytoma (26.3%), Cushing's syndrome (18.8%), non-secreting tumors (9.4%), and adrenal metastases (7.9%). Histologic examination confirmed 64 malignant lesions, of which 27 were adrenocortical carcinoma (ACC).

Most LA was performed for left-sided lesions (48.6%). A small proportion of patients required concomitant procedure (6.2%). Few patients needed conversion to OA (4%). Postoperative complications occurred in 15.6% of patients who underwent LA with no mortality. Few patients (2.5%) suffered complications classified as Clavien-Dindo grade 3 or higher. Reasons for conversion to OA included bleeding (from spleen capsule/artery, vena cava, renal vein, or adrenal vein), technical issues (tumor size, adhesions, difficult dissection, bowel injury), or medical complications. The authors demonstrated by multivariate analysis that tumor size ≥4.5 cm (OR=7.46, 2.18–25.47, P=0.001) and performance of a concomitant procedure (OR=3.958, 1.248–12.550, P=0.034) significantly increased odds of conversion to OA. In addition, tumor size ≥4.5 cm was associated with risk of adrenal capsule breach (OR=4.416, 1.628–11.983, P=0.004). Multivariate logistic regression analysis showed that intraoperative incident was a risk factor for conversion, and that conversion to OA was an independent predictor of morbidity.

During the study period, 52 different surgeons each performed on average 10 adrenalectomies (range 1–104 adrenalectomies per surgeon). Bilateral adrenalectomy was excluded from analysis as this procedure was performed exclusively by the most experienced surgeons. When surgeons were divided into junior and senior groups based on a cutoff of 30 unilateral adrenalectomies, the authors found by multivariate logistic regression that junior surgeons had a lower risk of intraoperative incident (OR=0.465, 0.28–0.78, P=0.004). When surgeon experience was determined by median number of cases performed, the authors found on multivariate analysis that surgeons with more experience operated on patients with a higher grade of preoperative morbidity and larger adrenal lesion size. The study by Coste *et al.* highlights several important aspects of selecting patients for LA by transabdominal approach (8,9). A lesion diameter >4.5 cm was associated with an increased risk of intraoperative incident, adrenal capsule breach, conversion to OA, and prolonged operative time and hospital LOS (8,9).

Other investigators showed that adrenal lesion size plays an important role in outcomes, but the exact lesion size that significantly increases the odds of conversion and/or complication may vary with patient characteristics, lesion histology, and surgeon experience. Studies show that lesion size over 5–6 cm predicts conversion to OA without impacting morbidity (1,10,11). Other studies demonstrate an increased risk for conversion to OA with greater morbidity when the adrenal lesion measures at least 8 cm (1). Publications report the feasibility of LA for benign adrenal lesions over 10 cm, despite the potential for greater risk (11,12). Many of these studies were performed in centers and by surgeons with a wealth of clinical experience in both LA and OA. Therefore, reported results may be valid only for surgeons with significant experience especially as adrenal lesion size increases beyond 4.5 cm and surely beyond 8 cm (1). In addition, the need for concomitant procedures—a surrogate for disease severity and/or case complexity as well as a predictor of conversion to OA and 30-day morbidity—may be a good indicator that such operations be performed in centers and by surgeons with significant experience.

Senior surgeons, as defined by Coste *et al.*, experienced more intraoperative complications compared to their junior colleagues; however, senior surgeons performed LA on higher risk patients, larger adrenal lesions, and bilateral adrenal lesions (8,9). A separate study concluded that surgeons with relatively low case volume (1–2 adrenalectomies per year) contribute 50% of the annual adrenalectomy volume in the United States (6,13). However, other data demonstrate that centers with low volume (<3 adrenalectomies annually) have an increased rate of intraoperative complications and conversion compared to higher volume centers (14). The study by Coste *et al.* provided data highlighting the relationship between surgeon experience and patient outcomes (8,9). Additionally, the authors go on to discuss potential prerequisites for teaching LA and indicators for referring patients to surgeons with

extensive LA experience. These two issues raised by the authors are worth further discussion.

Coste *et al.* seem to feel strongly that teaching LA requires an 'expert center', though the authors do not define this term further but do write, "Good practice for a surgical procedure can only be learned in an expert center" (8,9). This statement raises the issue of surgical training in uncommon procedures which may be further complicated by duty-hours restrictions and centralization of care.

While a challenging procedure, LA can and should be part of surgical residency training. However, not all surgical residency programs exist in hospitals with a high volume of adrenalectomies. In some instances, trainees may elect to complete sub-specialty fellowship training, though there are other avenues to gain sufficient LA experience such as senior surgeon mentorship and simulation exercises.

The learning curve for LA can be overcome through functional curricula, sufficient clinical experience, and critical supervision without compromising patient outcomes (15). An early report on learning curve found significantly shorter mean operative time and fewer intraoperative complications after the first 33 cases of transabdominal LA. The authors noted a trend toward lower risk of conversion to OA after the first 33 cases, but it did not reach statistical significance (16). Other authors concluded that at least 40–50 cases of LA are needed to shorten operative time and lower the risk of conversion to OA significantly (17). While these data provide an inflection point along the learning curve, they do not completely define clinical competency or proficiency in LA.

Case volume alone is not the only method (or perhaps the best way) to evaluate proficiency. Eto *et al.* expanded on the learning curve of three surgeons by investigating the impact of tumor histology on LA proficiency (defined as operative time of 200 minutes) (18). All three surgeons achieved proficiency but at different rates depending on the specific surgeon and tumor histology, suggesting that case volume alone is not a sufficient metric to define proficiency (18). In addition to tumor histology, Guerrieri *et al.* determined that LA operative time and conversion rate plateaued after 30 right and 40 left adrenalectomies suggesting that lesion side may play a role in the learning curve (19).

The operative approach to LA can impact the learning curve as well. Recently, Fukumoto *et al.* investigated the learning curve during single-site LA and concluded that outcomes stabilized at 30 adrenalectomies (20). Multivariate analysis revealed that during the first 29 adrenalectomies, tumor size (≥5 cm) predicted prolonged operative time. None of the examined factors predicted prolonged operative time among surgeons beyond the learning curve (≥30 adrenalectomies) (20). The learning curves of retroperitoneoscopic LA and robot-assisted LA vary by surgeon experience with transabdominal LA as well as other factors (21,22). Factors that contribute to variation along the learning curve of LA include case volume but also lesion size, histology, and location, as well as operative approach and surgeon experience with advanced laparoscopic procedures.

Surgeon specialty may also impact the learning curve of LA. Park *et al.* assessed the impact of surgeon volume and specialty on clinical outcomes after LA (23). Using the Nationwide Inpatient Sample, they reviewed all adults who underwent adrenalectomy in the United States from 1999 through 2005. Surgeons were defined by clinical volume (high *vs.* low) and surgical specialty. Authors found that more general surgeons were considered high-volume compared to urological surgeons (34.1% *vs.* 18.2%, P<0.01). General surgeons and high-volume surgeons regardless of specialty had fewer complications. After adjusting for patient and provider factors on multivariate analysis, only surgeon volume predicted complications (OR=1.5, P<0.01). The authors of this study felt patients with adrenal disease should be referred to high-volume surgeons regardless of surgical specialty (23).

Given that all these highlighted factors influence the learning curve of LA, it seems critical to assure surgical trainees receive the appropriate training. As many general surgery residency graduates pursue fellowship training, it is important for fellowships to meet the needs of the trainee, especially in LA. A recent survey of 201 graduates of fellowship council-accredited programs showed that 95% of respondents were satisfied with their operative experience overall. A majority (85%) of respondents who intended to learn a specific procedure felt competent in that procedure following graduation. However, graduates wished for more experience with uncommon minimally invasive procedures including LA (24).

So, if surgical trainees gain exposure to LA during surgical residency but not enough to feel competent, then garner sufficient experience in LA during fellowship to feel competent but not proficient, how do we adequately train surgeons to proficiency given limited time restraints and uncommonness of LA? If surgeons must train to proficiency in an 'expert center', then the surgical education community and surgeons with expertise in LA must collaborate to define competency and proficiency in LA as well as 'expert center' beyond case volumes. It is critical to include curricula, simulation-based training initiatives, feedback

metrics, and validated assessment tools not just operative volume or designation as an 'expert center' when designing, implementing, and assessing a cognitive and technical skills training program for LA.

The second matter raised by Coste *et al.* is their assertion that patients with larger adrenal lesions be referred to experienced (high-volume) surgeons due to increased risk for conversion and complications (8,9). On this point, outcomes data and expert opinion align. Studies highlight the importance of adrenal lesion size on LA outcomes, specifically the increased risk for conversion to OA and 30-day morbidity (1,6-9). Additional factors influence outcomes of LA as well, including adrenal lesion bilateralism, tumor histology, operative approach, need for concomitant procedures, and surgeon experience (1-11). While a surgeon may achieve competency and proficiency with LA in various ways, it seems reasonable that complex patients fare better in the hands of a surgeon significantly experienced (proficient) with LA.

In conclusion, LA continues to gain popularity among surgeons due to lower morbidity, shorter hospital LOS, and less pain following these procedures. Preoperative risk factors that may influence patient outcomes include tumor size, tumor histology and functionality, the need for concomitant procedures, and surgeon experience. The implementation of a dedicated curriculum for trainees is necessary to enhance surgeon performance in LAs. The recognition of these risk factors can aid in preoperative planning and help to optimize patient outcomes.

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