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Factors affecting the surgical approach and timing of bilateral adrenalectomy

Billy Y. Lan · Halit E. Taskin · Erol Aksoy · Onur Birsen · Cem Dural · Jamie Mitchell · Allan Siperstein · Eren Berber

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Abstract
Background Laparoscopic adrenalectomy has gained widespread acceptance. However, the optimal surgical approach to laparoscopic bilateral adrenalectomy has not been clearly defined. The aim of this study is to analyze the patient and intraoperative factors affecting the feasibility and outcome of different surgical approaches to define an algorithm for bilateral adrenalectomy.
Methods Between 2000 and 2013, all patients who underwent bilateral adrenalectomy at a single institution were selected for retrospective analysis. Patient factors, surgical approach, operative outcomes, and complications were analyzed.
Results From 2000 to 2013, 28 patients underwent bilateral adrenalectomy. Patient diagnoses included Cushing's disease ($n = 19$), pheochromocytoma ($n = 7$), and adrenal metastasis ($n = 2$). Of these 28 patients, successful laparoscopic adrenalectomy was performed in all but 2 patients. Twenty-three out of the 26 adrenalectomies were completed in a single stage, while three were performed as a staged approach due to deterioration in intraoperative respiratory status in two patients and patient body habitus in one. Of the adrenalectomies completed using the minimally invasive approach, a posterior retroperitoneal (PR) approach was performed in 17 patients and lateral transabdominal (LT) approach in 9 patients. Patients who underwent a LT approach had higher BMI, larger tumor size, and other concomitant intraabdominal pathology. Hospital stay for laparoscopic adrenalectomy was 3.5 days compared to 5 and 12 days for the two open cases. There were no 30-day hospital mortality and 5 patients had minor complications for the entire cohort.
Conclusions A minimally invasive operation is feasible in 93 % of patients undergoing bilateral adrenalectomy with 65 % of adrenalectomies performed using the PR approach. Indications for the LT approach include morbid obesity, tumor size >6 cm, and other concomitant intraabdominal pathology. Single-stage adrenalectomies are feasible in most patients, with prolonged operative time causing respiratory instability being the main indication for a staged approach.

Keywords Adrenal · Endocrinology · Surgical · Technical

Bilateral adrenal tumors account for 10 % of all adrenal diseases [1]. Until recently, the surgical options for bilateral adrenalectomy were very morbid [2]. Over the past decade, a minimally invasive approach has gained universal acceptance as the standard for bilateral adrenalectomy [3–5]. However, the optimal surgical approach to accessing the adrenal gland has not been well defined. Gagner et al. first described a laparoscopic transperitoneal adrenalectomy in 1992 that approached the adrenal gland with the patient in the lateral decubitus position [6]. Subsequently, Mercan et al. described a retroperitoneal

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B. Y. Lan (✉) · J. Mitchell · A. Siperstein · E. Berber
Department of General Surgery, Digestive Disease Institute, The Cleveland Clinic, Cleveland, OH, USA
e-mail: lanb@ccf.org

E. Berber
e-mail: berbere@ccf.org

H. E. Taskin · E. Aksoy · O. Birsen · C. Dural · J. Mitchell · A. Siperstein · E. Berber
Department of Endocrine Surgery, Endocrinology and Metabolism Institute, The Cleveland Clinic, 9500 Euclid Avenue F20, Cleveland, OH 44195, USA

approach that provided access to both adrenal glands without having to reposition the patient [7].

Although both approaches have been well described and utilized, the choice of lateral transabdominal (LT) versus posterior retroperitoneal (PR) approach has been based on surgeon preference [8, 9]. The LT approach has generally been preferred for patients with larger tumors, higher body mass index, and suspected malignancy [10]. The PR approach is preferred for patients with smaller tumors, lower BMI, and previous abdominal surgery [11, 12]. The lack of a need to reposition the patient has also made the PR approach the favored method for some surgeons. In addition, the decision whether to simultaneously remove both adrenal glands in one procedure or in a staged fashion has not been well studied. Overall, a clear algorithm on the optimal approach and timing of bilateral adrenalectomy has not been defined. In this paper, we analyzed a cohort of patients who underwent bilateral adrenalectomy at a single institution with the aim to identify patient and operative factors affecting the feasibility and outcomes of bilateral adrenalectomy.

Materials and methods

Patient selection

Between 2000 and 2013, all patients who underwent adrenalectomy at a single, tertiary institution were identified from an IRB-approved database. Patients who underwent bilateral adrenalectomy were selected. Pre-operative patient characteristics and operative outcomes including operative time, estimated blood loss, length of stay, and 30-day morbidity and mortality were compared for analysis. Continuous variables were compared using either Welch's two-sample *t* test or Wilcoxon's rank-sum test, as appropriate. Categorical variables were compared using either Pearson's Chi-squared test or Fisher's exact test, as appropriate.

Surgical technique

Lateral transabdominal adrenalectomy

After induction of anesthesia and intubation, the patient was laid in the lateral decubitus position as pictured in Fig. 1. The costal margin and anterior superior iliac spine (ASIS) were palpated and the first trocar was placed two finger-breadths below the inferior costal margin along the anterior axillary line, approximately halfway to the umbilicus. Optical trocar entry was performed through a 12-mm incision at this site to be used as the camera port. An angled 45° laparoscope was routinely used for optimal visualization. Two additional 5-mm trocars were placed, one lateral and one medial to the camera port. An ultrasonic scalpel was issued for tissue dissection. Upon removal of the first adrenal gland through the 12-mm trocar site, the patient was repositioned for removal of the contralateral adrenal gland.

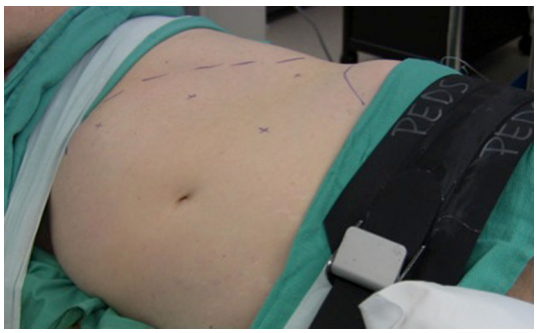

Fig. 1 Patient positioning and trocar sites for laparoscopic lateral transabdominal approach

Fig. 2 Patient positioning and trocar sites for laparoscopic posterior retroperitoneal approach

Posterior retroperitoneal adrenalectomy

For this approach, the patient was placed in the prone jackknife position on a Wilson frame. First, the anatomical landmarks for the tip of the 12th rib and ASIS were marked for both the right and left side as pictured in Fig. 2. The first trocar was placed just inferior to the tip of the 12th rib through a 12-mm incision for a balloon trocar to be used as the camera port. Next, two additional 5-mm trocars were placed, one medial and one lateral to the camera port. Upon removal of the first adrenal gland, the same incisions were then made on the other side of the patient for the removal of the contralateral adrenal gland.

Table 1 Patient characteristics and operative outcomes of patients who underwent bilateral adrenalectomy

	$n = 28$
Age (years)	58.2 ± 3.5
Female gender (%)	16 (57 %)
ASA (median)	3
Body mass index (kg/m^2)	32.2 ± 9.7
Diagnosis (%)	
Cushing's	20 (72 %)
Pheochromocytoma	6 (21 %)
Metastasis	2 (7 %)
Tumor size (cm)	6.5 ± 3.2
Approach (%)	
Laparoscopic	26 (93 %)
Posterior retroperitoneal	17 (65 %)
Lateral transabdominal	9 (35 %)
Open	2 (7 %)
Single stage/two-stage	23/3
Operative time (min)	317 ± 113
Estimated blood loss (mL)	71 ± 296
Length of stay (days)	3.5 ± 3.4
30-day Complications	
Morbidity (%)	5 (%)
Mortality (%)	0

Continuous data are presented as mean ± standard deviation and categorical data as counts and variables

Results

From 2000 to 2013, a total of 287 patients underwent adrenalectomy. Of these, 28 patients (10 %) underwent bilateral adrenalectomy. Indication for surgery included Cushing's disease in 20 patients, pheochromocytoma in 6 patients, and adrenal metastasis in 2 patients. Patient characteristics are listed in Table 1. The patients were mostly female with an average BMI of 32, median ASA of 3, and average tumor size of 6.5 cm.

Bilateral adrenalectomy was performed using a minimally invasive approach in 26 patients, with 23 patients undergoing a single stage procedure. The PR approach was performed in 17 patients and LT approach in 9 patients. All laparoscopic bilateral adrenalectomies were completed without the need for conversion to an open laparotomy. An elective open approach was performed in 2 patients due to pre-operative imaging indicating local invasion of the tumor of the inferior vena cava in 1 patient and the presence of a retroduodenal paraganglioma from von Hippel-Lindau syndrome in another.

Twenty-three (88 %) of the 26 patients underwent a single-stage bilateral adrenalectomy. Three patients underwent a staged approach due to prolonged operative time. In two patients, operative time of 313 and 587 min led to intraoperative respiratory deterioration. In the other patient, a two-stage approach was performed due to difficult dissection of the first adrenal gland that led to an operative time of 570 min.

Table 2 Comparison of patient characteristics and operative outcomes of patients who underwent laparoscopic lateral transabdominal versus posterior retroperitoneal adrenalectomy

	Lateral ($n = 9$)	Posterior ($n = 17$)	p value
Age (years)	54.9 ± 14.3	59.7 ± 17.7	0.46
Female gender (%)	6 (67 %)	10 (59 %)	>0.99
ASA (median)	3	3	0.10
Body mass index (kg/m^2)	36.7 ± 13	30.1 ± 6.9	0.19
Diagnosis			0.55
Cushing's	6 (67 %)	14 (82 %)	
Pheochromocytoma	3 (33 %)	2 (12 %)	
Metastasis	0	1 (6 %)	
Tumor size (cm)	7.8 ± 3.4	5.5 ± 2.4	0.09
Operative time (min)	374 ± 157	334 ± 93	0.52
Estimated blood loss (mL)	102 ± 157	74 ± 105	0.40
Single stage (%)	7 (78 %)	16 (94 %)	0.27
Length of stay (days)	3.5 ± 2.1	2.7 ±	0.73
30-day complications			
Morbidity (%)	2 (22 %)	2 (12 %)	0.59
Mortality (%)	0	0	

Patients who underwent a LT approach had larger tumors (7.8 vs. 5.5 cm), higher BMI (36 vs. 30), and a need for a concomitant splenectomy (1 patient) compared to patients who underwent a PR approach (Table 2), although none were statistically significant. Patients who underwent laparoscopic bilateral adrenalectomy stayed in the hospital an average of 3.5 days, compared to 5 and 12 days for the two open cases. The 30-day mortality for all bilateral adrenalectomy patients was zero with 5 (18 %) post-operative complications. These complications included new-onset atrial fibrillation, respiratory insufficiency requiring non-invasive ventilation, pleural effusions, urinary tract infection, and readmission. Sixty percent of these complications involved patients with Cushing's disease.

Discussion

Over the last decade, a minimally invasive approach to bilateral adrenalectomy has gained widespread acceptance. Our study of a relatively large, single center series indicates that a laparoscopic lateral transabdominal or posterior retroperitoneal adrenalectomy is feasible in a single stage setting in most patients with bilateral adrenal disease.

Previous studies of bilateral adrenalectomy have been mostly limited to case reports [13, 14]. The largest series in

the literature of bilateral adrenalectomy by Takata et al. [15] included a similar patient population with mostly Cushing's disease undergoing a LT approach. Our study, however, consists of patients who underwent bilateral adrenalectomy through both an LT and PR approach. Results from the two studies were comparable in operative times, estimated blood loss, length of hospital stay, and minor complication rates. The conversion to an open adrenalectomy was not needed in either study.

The majority of the post-operative complications in this study were minor. Though the overall complication rates for all patients undergoing bilateral adrenalectomy were similar compared to other studies, three out of 5 patients with complications occurred in patients with Cushing's disease [15, 16]. This finding has been reported in prior studies [15]. The management of Cushing's disease patients is challenging and complex as patients are often on long-term glucocorticoid therapy and as a result severely debilitated prior to surgery. Due to their underlying medical condition, patients with Cushing's disease are at increased risk for post-operative complications leading to prolonged hospitalizations [17].

The two main subgroups of patients requiring bilateral adrenalectomy were patients with Cushing's disease and pheochromocytoma. In our experience, patients with pheochromocytoma usually present with a single discrete mass and lesser fat deposition in the retroperitoneum. Although patients with pheochromocytoma are at increased risk for intraoperative hemodynamic instability, bilateral adrenalectomy has been easier compared to patients with Cushing's disease for these reasons as represented in the average operative time of 361 min for patients with Cushing's disease and 326 min for patients with pheochromocytoma.

The main advantage of the PR approach is direct access to the adrenal glands in the retroperitoneum, limiting the need for visceral mobilization and patient repositioning. This in turn has been reported to reduce overall blood loss, injury to intraabdominal organs, and operative time compared to the LT approach [9]. However, there are limitations with the PR approach due to the small operative space in the retroperitoneum. As a result, tumors greater than 6 cm are preferably approached in the lateral transabdominal position. An algorithm reported by our group for selection of the LT or PR approach for a given patient indicates that BMI is predictive of operative time in the LT approach, while the amount of perinephric fat and distance of tumor to the superior pole of the kidney are predictive of operative time for the PR approach [18]. This same algorithm for unilateral adrenalectomy was applied to the current study for bilateral adrenal tumors when deciding on a LT or PR approach. In our study, patients undergoing the LT approach had larger tumors and higher BMI but 4 out of the 17 patients who underwent the PR approach had a BMI > 35. This indicates that rather than weight, the patient's body habitus, specifically the thickness of the soft tissue in the lower back, best determines the feasibility of either approach.

The ideal approach for bilateral adrenalectomy is still debated and data for a single versus two-staged removal of bilateral adrenal tumors remain limited. Our data indicate that intraoperative patient instability is the main limiting factor in determining the timing of bilateral adrenalectomy, mainly dependent on the length of time needed for removal of the first adrenal gland. In our study, intraoperative hypercarbia and respiratory decompensation due to prolonged operative time prompted a staged approach. Though a prolonged operative time of >200 min seemed to predict the need for a staged approach, the sample size in this study is small for a definitive recommendation based on operative time.

In summary, a minimally invasive approach to bilateral adrenalectomy is universally accepted to be safe. Our study indicates that bilateral adrenalectomy using either the lateral transabdominal or posterior retroperitoneal approach is feasible. When patients with bilateral adrenal tumors are selected for either a LT or PR approach using the same algorithm used for patients with unilateral tumors [18] both laparoscopic LT and PR adrenalectomy results in good operative outcomes with a single-stage operation possible in most patients.

Disclosures Lan, Taskin, Aksoy, Birsen, Dural, Mitchell, Siperstein, and Berber have no conflicts of interest or financial ties to disclose.

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