

Posterior Retroperitoneoscopic Adrenalectomy

Preferred Technique for Removal of Benign Tumors and Isolated Metastases

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Objective: Posterior retroperitoneoscopic adrenalectomy (PRA) is a minimally invasive approach to removal of the adrenal gland. This anatomically direct approach, popularized by Walz, minimizes dissection and affords early access to the adrenal vein. We report the largest experience to date of PRA in the United States.

Methods: The prospective endocrine surgery database at a tertiary care center was used to capture all patients who underwent PRA between October 2005 and February 2008. All PRA procedures were performed using a 3-trocar technique with the patient in a prone jackknife position.

Results: Sixty-eight PRAs were performed in 62 patients; there were 6 conversions (3 video-assisted and 3 open). Indications for adrenalectomy were functional tumors in 43 patients (20 pheochromocytomas, 13 Cushing disease or syndrome, and 10 others), nonfunctional cortical adenomas in 4, and isolated adrenal metastases in 15. Mean tumor size was 3.4 cm. Complications occurred in 11 patients (16%), with no perioperative deaths. In 34 (55%) patients, there was a relative contraindication to an anterior approach. Additionally, 20 patients (38%) had a body mass index greater than 30. Median operating time was 121 minutes.

Conclusion: PRA is safe, avoids intra-abdominal adjacent organ mobilization, is unaffected by the presence of intra-abdominal adhesions, and is possible in obese patients. PRA may be the preferred technique for removing benign adrenal tumors and isolated metastases.

(*Ann Surg* 2008;248: 666–674)

Since its first description in 1992, transabdominal laparoscopic adrenalectomy (LA) has become the gold standard for the surgical removal of benign adrenal neoplasms.^{1,2}

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Supported by the Faith Fund for Endocrine Surgery Research and Education in the Department of Surgical Oncology, University of Texas, MD, Anderson Cancer Center.

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ISSN: 0003-4932/08/24804-0666

DOI: 10.1097/SLA.0b013e31818a1d2a

Traditional LA is performed with the patient on their side using insufflation pressures of 12 to 15 mmHg. In contrast, posterior retroperitoneoscopic adrenalectomy (PRA) is performed with the patient in the prone jackknife position with a specially formed abdominal support structure. The first report of retroperitoneal adrenalectomy included 11 patients and was published in 1995 by Mercan et al.³ Their technique used a balloon expander and four 10-mm trochars. Other small series of retroperitoneal adrenalectomy were reported in the mid 1990s but the technique was not widely adopted largely because of the inability to gain adequate exposure in the retroperitoneal space with standard insufflation pressures.^{4,5} Higher insufflation pressures were not considered at that time because of their unknown consequences, especially the potential for compression of the inferior vena cava (IVC) with a resulting decrease in venous return and systemic hypotension. However, Giebler and Walz et al from Essen, Germany observed that patients who underwent PRA in the prone position had normal filling pressures and no evidence of decreased cardiac output despite the use of high insufflation pressure (20 mmHg).^{6,7} To explain this observation, they hypothesized that intraperitoneal and retroperitoneal carbon dioxide insufflation evoked fundamentally different cardiovascular changes because of a difference in the pressure gradient between the inferior and the superior vena cava depending on the compartment (peritoneum or retroperitoneum) that was insufflated and the insufflation pressure applied. In a subsequent manuscript, Giebler and Walz et al studied intrathoracic and extrathoracic IVC pressures in patients who underwent laparoscopic cholecystectomy and PRA and found that decreased cardiac filling occurred with intraperitoneal insufflation pressures greater than 15 mmHg.⁸ In contrast, cardiac filling was not impaired with retroperitoneal insufflation pressures greater than 15 mmHg. Their data supported the hypothesis that retroperitoneal carbon dioxide insufflation evoked different effects on vena cava pressure gradients than did intraperitoneal insufflation and was consistent with the clinical observation that high-pressure retroperitoneal insufflation did not alter cardiovascular hemodynamics and was well-tolerated. Indeed, the ability to use insufflation pressures of 20 to 24 mmHg was necessary to expand the retroperitoneal space and facilitate a bloodless field for dissection.

Walz et al recently reported their updated experience with PRA and have demonstrated that the operation is safe and is associated with decreased operative times and rapid patient recovery.⁹ Advantages of PRA include direct exposure of the adrenal gland without the need for adjacent organ displacement and improved visualization and access to the adrenal vein. However, most surgeons have not adopted PRA because of perceived concerns over limited exposure because of the modest size of the retroperitoneal space and the absence of familiar anatomic landmarks.¹⁰ After observing Dr. Walz and his surgical team, we began using this approach for adrenalectomy in late 2005. Since then, PRA has become our preferred technique for removal of relatively small, benign adrenal tumors and adrenal metastases. The combined experience of our endocrine surgery group is reported herein and represents the largest experience with this technique in the United States to date.⁵

PATIENTS AND METHODS

Patients

Between October 2005 and February 2008 the prospectively maintained endocrine surgery database in the Department of Surgical Oncology at The University of Texas, MD Anderson Cancer Center was used to review data on all patients who underwent PRA. Institutional review board approval was obtained before data retrieval and analysis. No patient underwent PRA if there was a preoperative suspicion of adrenal cortical carcinoma based on clinical presentation or radiographic findings.

Intraoperative conversion to a video-assisted procedure was defined as enlargement of the middle trocar incision site to 5 to 7 cm to allow placement of a single blade of the Thompson retractor (Thompson Surgical Instruments, Inc; Traverse City, MI). In such cases, the adrenal gland was removed videoscopically but through a single incision without trocars. Intraoperative conversion to an open procedure was defined as one that required a standard anterior or posterior adrenalectomy incision in which the operation was completed without a video scope.

Operating time was recorded from the anesthesia record and was defined as the time from skin incision to application of the final dressing and removal of all drapes. Estimated blood loss was also recorded from the anesthesia record. Hospital stay was calculated by including the day of surgery as day 1 and by not counting the day of discharge. Date of operation was used to divide the patients into 2 groups; group 1, October 2005 to December 2006 and group 2, January 2007 to February 2008. This breakpoint was chosen as it evenly divided the patients into those operated upon in the first half (group 1) of our experience compared with those operated upon in the second half (group 2). Obesity was defined as a body mass index (BMI) of 30 or greater.

Statistical Analysis

The Wilcoxon rank sum test was used to compare operating time for unilateral PRA between patients grouped by sex, age, BMI (calculated as weight in kilograms/(height in meters) × (height in meters)), primary versus metastatic

neoplasm, functional status of the neoplasm, and date of operation. For unilateral PRA, the Wilcoxon rank sum test was used to compare operating time between patient groups based on gender, age, BMI, origin of the tumor (primary adrenal neoplasm or a metastasis), tumor size, functional status, and date of operation. A *P* value <0.05 was considered statistically significant. Statistical analyses were done using SPSS version 12.0 (SPSS Inc, Chicago, IL).

Operative Technique

The PRA operative technique as described by Walz et al was used in all cases.^{7,9} All operations were performed by 1 of 3 senior endocrine surgeons experienced in open and laparoscopic adrenalectomy. All 3 surgeons participated in an organized educational program, which involved assisting with a series of cases in Germany followed by a reverse site visit in which Dr. Walz critiqued the procedures performed in Houston. For the initial 50% or more of the cases reported herein, 2 surgeons scrubbed on each case; we found it particularly important to have an experienced operator at the camera position. Following the induction of general endotracheal anesthesia in the supine position, the patient was placed in a prone jackknife position for PRA. The patient was positioned on a Cloward table saddle (Cloward Surgical Saddle, Surgical Equipment International, Honolulu, Hawaii) that is commonly used as a spinal surgery frame but which we used as an abdominal support device to allow the ventral abdominal wall to hang anteriorly without constraint. The hips and knees were carefully positioned at approximately 90-degree angles relative to the spine and femur with proper padding at pressure points. It was important to limit the pressure on the knees (especially in large, overweight patients) to prevent anterior displacement of the hips which can limit instrument mobility.

Palpation of the 12th rib was used to guide the placement of a 1.5-cm transverse incision just beneath the tip of the rib. The soft tissues were divided sharply with scissors and the retroperitoneal space was entered. Using the index finger, a small space was developed deep to the ribs and diaphragm within the retroperitoneum. With an index finger inside the retroperitoneal space, the medial (10 mm) trocar was then inserted along the para-spinal musculature. This trocar was angled cephalad at approximately 45 degrees and pointed directly at the anatomic location of the adrenal gland. The lateral 5-mm trocar was inserted in a similar fashion 4 to 5 cm lateral to the initial incision and beneath the 11th rib. A blunt trocar with an inflatable balloon was then introduced into the middle trocar site to anchor the trocar. The pneumoretroperitoneum was created with CO₂ through high-flow tubing and maintained at a pressure of 20 to 24 mmHg.

Retroperitoneoscopy was performed using a 10-mm/30-degree video scope, initially introduced into the middle trocar. After the creation of the retroperitoneal space, the video scope was placed into the medial trocar. The retroperitoneal space beneath the diaphragm was created using sharp and blunt dissection. Gerota's fascia was entered and the superior border of the kidney identified (Fig. 1). The paraspinous muscles, the posterior surface of the liver or spleen as seen through the peritoneum, and the upper pole of the kidney

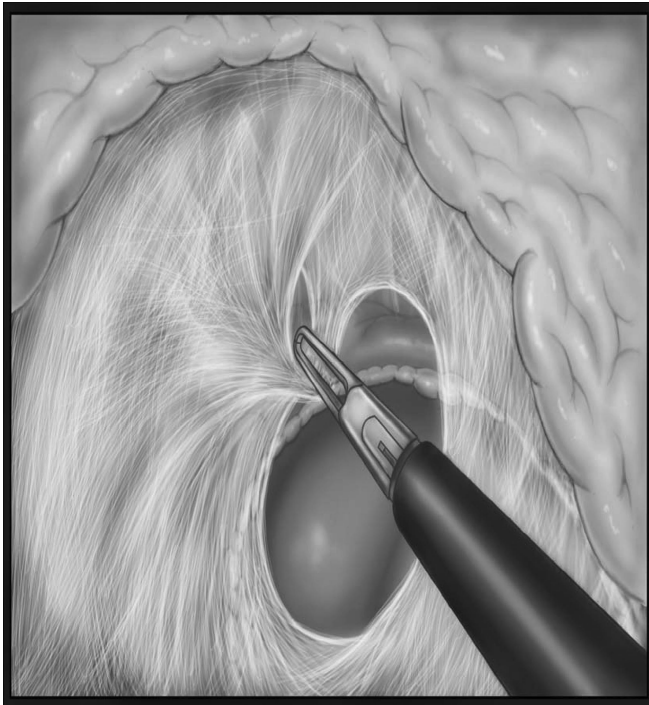


FIGURE 1. Right-sided PRA. Illustration depicting immediate visualization of retroperitoneal space upon entry with the videoscope and retractor.

were identified to serve as landmarks. The tissue superior to the kidney, which contains the lower aspect of the adrenal gland was completely separated from the kidney (Fig. 2). It is critically important to completely separate the adrenal from the superior border of the kidney at this time in the operation when the adrenal is still attached superiorly and medially. The upper pole of the kidney usually needs to be retracted in a caudal direction by an instrument in the medial or lateral trocar.

After the adrenal gland was separated from the upper pole of the kidney, medial mobilization was completed. The adrenal vein was identified, clipped, and divided. On the left side, the phrenic vein was often preserved. On the right side, the posterior approach to the IVC greatly facilitated exposure of the right adrenal vein and its ligation and division. The posterior, lateral and diaphragmatic dissection of the adrenal gland was largely completed using the En-seal (SurgRx Inc, Redwood City, CA) or the Harmonic scalpel (Ethicon Endosurgery, Cincinnati, OH). The lack of a significant amount of smoke with the En-seal device was found to be advantageous. When the adrenal was grasped to facilitate retraction, it was typically held by the stump of the adrenal vein. When the adrenal was completely separated from its retroperitoneal attachments, it was placed in an endocatch device and removed through the middle trocar site. No gland required morcellation but on occasion, the middle trocar site was minimally enlarged to facilitate specimen removal.

RESULTS

Patient and tumor characteristics are summarized in Table 1. Total adrenalectomy was performed in all cases.

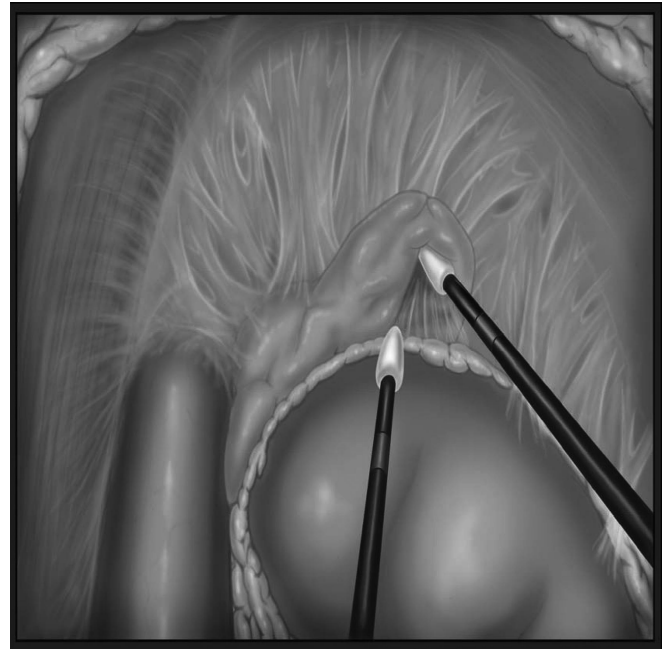


FIGURE 2. Right-sided PRA. Illustration showing elevation of inferior border of adrenal gland while maintaining downward pressure on the right kidney.

TABLE 1. Patient and Tumor Characteristics for the 62 Patients Who Underwent PRA

Characteristics	No. Patients (%)
Gender	
Male	29 (47)
Female	33 (53)
Functional primary adrenal neoplasms	43 (69)
Conn syndrome	8
Cushing disease	3
Cushing syndrome	10
Virilizing	2
Pheochromocytoma	20
Nonfunctional	4 (7)
Metastasis	15 (24)
Lung	6
Melanoma	4
Breast	2
Other	3
Unilateral	56 (90)
Left	33
Right	23
Bilateral	6 (10)
Weight	
BMI ≥30	27 (44)
BMI <30	35 (56)

These 68 PRAs performed by our group of 3 endocrine surgeons represent 73% of all (n = 86) laparoscopic adrenalectomies and 36% of all (n = 190) adrenalectomies performed at our institution by all surgeons during the study

period. The 4 nonfunctioning cortical neoplasms, which were found to be benign cortical adenomas on final pathologic evaluation included: a 4-cm cortical neoplasm in a patient who could not undergo an anterior operation because of multiple prior complications, including reoperation and small bowel fistula following gynecologic surgery; a 2-cm adrenal nodule that preoperatively was thought to be an isolated metastasis; a 3-cm cortical neoplasm in a patient that would not accept a course of observation; and a 9-cm hemorrhagic cyst thought to represent hemorrhage from a small benign cortical adenoma, which failed to resolve with a course of observation. There were 3 additional adrenal neoplasms (in 2 patients) greater than 6 cm in maximum dimension including 1 patient with a unilateral pheochromocytoma and 1 patient with bilateral testosterone producing cortical adenomas.

PRA was performed successfully in 62 of the 68 planned adrenalectomies. In 34 (55%) of the 62 patients, there was a history of previous abdominal surgery which could be considered a relative contraindication to an anterior laparoscopic approach; 18 (53%) of these 34 patients had undergone operations other than routine biliary or gynecologic surgery. There were no perioperative deaths and no patient required reoperation. Overall, 62 (92%) of 68 adrenalectomies were successfully performed using the intended posterior retroperitoneoscopic approach. Conversion to an open or a posterior video-assisted procedure was required for 6 adrenalectomies performed in 5 patients (4 left sided; 1 bilateral). Conversion to an open operative approach was necessary in 3 (4%) of the 68 adrenalectomies owing to the inability to maintain hemostasis (1), failure to progress in a patient with chronic lung disease who required a relatively brief operation (1), and failure to progress in an obese patient with an infiltrative adrenal metastasis. Conversion to a posterior video-assisted operation was necessary in 3 (4%) of the 68 adrenalectomies and was because of inadvertent trocar placement into the pleura and failure to obtain adequate insufflation (1), and Cushing-related extensive retroperitoneal adipose tissue resulting in failure to progress (2 adrenal glands in one patient). Of the 5 patients who required conversion, 3 were in group 2 and 3 were obese.

Operative times for the 52 patients who underwent successful unilateral PRA are included in Table 2; the 10 patients who underwent bilateral adrenalectomy and/or required conversion were excluded. As expected, the median operative times for the cases that required conversion was increased in comparison with the 52 unilateral adrenalectomies performed successfully. The 3 cases that required conversion to an open operation had a median operating time of 178 minutes. The operating time for the unilateral video-assisted procedure was 113 minutes and 279 minutes for the video-assisted bilateral adrenalectomy. In the latter patient, both sides were initiated endoscopically and both required conversion to the video-assisted technique.

Postoperative complications in addition to the conversions mentioned above occurred in 5 patients and included acute respiratory distress and right pleural effusion (1), urinary retention (2), superior vena cava syndrome (1), and a retroperitoneal hematoma (1). The latter patient required a

TABLE 2. Comparison of Operating Times by Patient and Tumor Characteristics in the 52 Patients Who Underwent Unilateral PRA*

Characteristic	No. Patients (%)	Operating Time in Minutes		P†
		Range (Min–Max)	Median	
Sex				0.15
Male	25 (48)	77–226	122	
Female	27 (52)	61–206	103	
Age				0.85
≤50 yr	22 (42)	65–226	122	
>50 yr	30 (58)	61–199	116	
Side of PRA				0.36
Left	31 (60)	61–206	103	
Right	21 (40)	71–226	124	
Obesity				0.77
Obese (BMI ≥30)	27 (44)	68–206	113	
Not obese (BMI <30)	35 (56)	61–226	122	
Functional status				0.81
Functional	35 (67)	61–226	115	
Nonfunctional	17 (33)	28–199	113	
Tumor size				0.23
≤4.0 cm	39 (75)	61–226	103	
>4.0 cm	13 (25)	68–206	125	
Metastatic vs. primary lesion				0.94
Metastatic	13 (25)	36–199	115	
Primary	39 (75)	61–226	113	
Study group				0.95
Group 1	26 (50)	68–199	117	
Group 2	26 (50)	61–226	114	

*Ten patients who underwent conversion and/or bilateral adrenalectomy are excluded.

†Wilcoxon rank sum test.

transfusion of 2 units of packed red blood cells. The patient who experienced acute respiratory distress responded to medical management and did not require intubation or other invasive interventions and recovered quickly. The patients with urinary retention were treated with a Foley catheter and both remained hospitalized for 1 extra day. The single case of superior vena cava syndrome was an exacerbation of a preexisting venous occlusion; venous congestion of the upper torso and face was noted in the recovery room. This complication was likely due to patient positioning (prone jackknife position) for 2 hours; the patient was anticoagulated and had no long-term sequelae. Of the 5 patients who experienced perioperative complications, 3 were in group 2. Overall, of the 10 patients who required either conversion or experienced a perioperative complication, 4 were in group 1 and 6 were in group 2.

Two additional patients developed palpable subcutaneous emphysema of the neck and chest but remained asymptomatic. These findings required no treatment, did not prolong their hospital stay, and were not considered complications. Two patients with long-standing refractory Cushing disease after failed pituitary operations have developed suspected biochemical evidence of recurrent disease suggesting that a

small portion of adrenal cortex may have been left at the time of surgery; both were in group 2. At the time of surgery and pathologic evaluation of the surgical specimen, evidence of subtotal resection was not appreciated. However, in both cases, the operations were difficult because of copious retroperitoneal fat from longstanding Cushing disease.

All pheochromocytomas and cortical neoplasms were histologically benign and no patient has clinical evidence of malignant disease. No patient underwent PRA for a primary adrenocortical carcinoma. Metastases from the known primary tumor were confirmed in all 15 patients who underwent PRA for metastases to the adrenal gland.

DISCUSSION

We describe 68 adrenalectomies performed by the posterior retroperitoneoscopic approach in 62 patients representing the largest series reported in the United States.⁵ Our conversion rate of 9% overall (4% to an open adrenalectomy) is lower than that reported in the early experience of Walz et al (17%).⁷ We attribute this to an organized educational program that involved observation/assisting Dr. Walz in Germany followed by a reverse site visit by Dr. Walz to the MD Anderson Cancer Center in Houston. In addition, the 3 faculty surgeons involved are senior endocrine surgeons who have a large experience with open (anterior and posterior) adrenalectomy and conventional transabdominal laparoscopic adrenalectomy. The system employed herein for the transfer of a new operative technique to another institution serves as a model for those interested in emerging technologies. It will be important that hospital credentialing committees and issues involving malpractice coverage do not impede educational transfer especially with respect to the enormous value of a reverse site visit. Regarding the complexity of having guest surgeons participate in operative procedures (eg, hospital credentialing), surgeons in the United States are clearly disadvantaged in contrast to our European colleagues.

Advantages of PRA include the ability to avoid mobilization of intra-abdominal solid organs such as the colon, spleen and pancreas, and liver and the ability to avoid having to deal with intra-abdominal scar tissue and adhesions. These advantages are particularly helpful in the setting of a patient with a history of multiple previous operations.¹¹ PRA is confined to the retroperitoneum, penetrates neither the pleural nor the abdominal cavity, and is particularly attractive for patients requiring bilateral adrenalectomy because it eliminates the need for patient repositioning. This series confirms that the technique can be successfully performed outside of Germany.

Important steps in the success of PRA include proper trocar placement, identification and gentle downward retraction of the kidney, and maintenance of the horizon by an experienced assistant controlling the camera (especially important when dealing with an anatomic region that is unfamiliar). In addition, after the adrenal is separated from the kidney, it is important to next identify and divide the adrenal vein whereas the adrenal gland remains attached superiorly and laterally. Walz has described several key technical details that simplify PRA.¹² First is the application of relatively high

CO₂ insufflation pressures (up to 24 mmHg) to improve visibility while creating an adequate retroperitoneal working space. Without this relatively high CO₂ insufflation pressure, exposure is difficult or impossible. Additionally, the higher CO₂ pressure tends to tamponade bleeding from small vessels, minimizing blood contamination of the field, and improving visibility. This insufflation pressure does not result in a clinically evident decline in venous return or cardiac output despite the obvious compression of the IVC seen when performing right-sided PRA.^{6,8} As suggested by Walz et al, we created a dedicated operating room team (at all levels), which included a senior anesthesiologist who specialized in adrenal anesthesia for functioning adrenal tumors (D.L.K). The complexity of patient positioning, instrumentation, and all aspects of anesthesia management were clearly minimized by having such a dedicated group of specialists.

PRA requires a cognitive “reorientation” for the surgeon as the retroperitoneal structures are not commonly visualized from this “backdoor” view. The posterior retroperitoneal space is relatively small, and there are few familiar landmarks. However, once the surgeon becomes comfortable with the procedure, there are clear landmarks to direct the operation. Importantly, the camera must stay focused on the region of the adrenal gland, even before the adrenal is visualized. We found it important, especially early in our experience, to have an experienced surgeon control the camera to allow a pair of experienced eyes to maintain anatomic perspective and a properly oriented horizon. In particular, the upper pole of the kidney, para-spinal muscles, diaphragm, white areolar perirenal tissue, and the medial adrenal surface are important landmarks. Identification of the adrenal gland buried in the perinephric fat is the major technical difficulty related to PRA and perhaps is most influenced by the learning curve. If the abundant perirenal fat is hazardedly dissected in an attempt to identify the adrenal gland, the operative field can soon become obscured by hemorrhage. It is imperative that the relatively bloodless, avascular plane between the inferior border of the adrenal gland and the parenchymal surface of the upper pole of the kidney be recognized early in the operation. Within this plane, white, loose areolar tissue joins the renal fascia with the surface of the perirenal-periadrenal fat. Tiny vessels within the septations of fat should be divided with coagulation instruments to control bleeding in the plane of dissection. Next, identification of the medial surface of the adrenal tumor or gland early in the operation is critical and provides a constant anatomic orientation for further manipulation.¹³ Interestingly, of the 10 patients who experienced either conversion or a complication, 4 were in group 1 and 6 were in group 2. Further, there was no difference in operative time between groups; all suggesting that we were likely accepting more challenging cases as our confidence in the technique developed (or that the learning curve is longer than we suspect).

Our mean operating time of 121 minutes for unilateral PRA is comparable with the times reported in larger series of anterior and lateral laparoscopic adrenalectomy^{14–16} and to the mean time of 124 minutes (45–225 minutes) reported by

Walz et al in his initial series of PRA.¹² Importantly, operating time in this report was calculated from the anesthesia record and not from the operative note dictated by the surgeon. The 3-day mean hospital stay was comparable with, or shorter than, the hospital stays reported in the past from north American centers for anterior or retroperitoneal LA.¹⁴ The 3-day hospital stay may be because of, in part, the large percentage of functioning tumors in our study, many of whom required postoperative medical management. For example, patients with long-standing Cushing disease or those with pheochromocytoma on high-dose blockade often require a few days of medical management before hospital discharge. Morbidity in our series was also no different from reports of other approaches to adrenalectomy.^{13,16} We believe that the overall advantage to the patient including minimal postoperative discomfort, early return of bowel function (no ileus), and early discharge are difficult to achieve with other techniques especially after the learning curve has been conquered.

Walz et al has recommended caution in attempting PRA on morbidly obese patients. The inability to expand the retroperitoneum in these patients may limit the space that can be created and may make exposure extremely difficult. We found this to be true if the ventral abdominal contents are not free to fall with gravity between the lateral cushions of the bed attachment used to provide hip support. An abundance of dorsal subcutaneous fat in morbidly obese patients hinders the 45-degree angle of the camera against the posterior iliac crest especially when the hips are large. This accounted for conversion to the posterior open (2) and the posterior video-assisted technique (1) in a total of 3 (11%) of the 27 obese patients in this series.

Because the risks of malignancy and rupture increase with tumor size, and because larger tumors are more difficult to manipulate in the limited retroperitoneal space, we reserve PRA for patients with suspected benign primary adrenal neoplasms, or adrenal metastases no larger than 6 cm in greatest diameter. Although Walz and his group recently reported that PRA can successfully be used to remove giant tumors, they stressed the necessity of having extensive experience (they have performed more than 500 adrenalectomies) before attempting removal of such tumors.^{9,17}

In 2 patients with profound cortisol excess (Cushing disease in 1 and ectopic adrenocorticotrophic hormone in the other), biochemical recurrence has occurred. Both had extremely fibrotic glands nestled within copious fat and in a background of very fragile tissues despite preoperative treatment with metyrapone. Both also had very difficult operations because of changes in body habitus, which were Cushingoid-related. We assume that the return of cortisol production is a result of residual macroscopic disease left in situ at the time of PRA. These patients are among the most challenging patients whom a surgeon will see referred for adrenalectomy and one should not attempt a PRA in such patients until one has developed an adequate level of confidence with the technique.

We conclude that PRA is a safe and attractive option for minimally invasive adrenalectomy. Proper patient positioning, optimal trocar placement, high-pressure CO₂ insufflation,

and early identification of the bloodless plane between the upper pole of the kidney and the inferior border of the adrenal gland are all critically important and represent key aspects of the learning curve for this operation. The ability to visit a center with expertise in the technique is crucial to successfully adopting this method of adrenalectomy. Because PRA provides direct access to the adrenal glands, it may be superior to the anterior and lateral laparoscopic approaches in some patients with benign adrenal tumors or small metastases. The benefits of this technique (over others) in terms of operative time, ease and quality of the dissection, and length of hospital stay, will likely be user dependent and based on the experience and background of the surgeon. In our practice, PRA has rapidly become the approach of choice for the majority of patients who require unilateral or bilateral adrenalectomy.

ACKNOWLEDGMENTS

The authors thank Dr. Martin Walz for his unique surgical skill, dedication to the art and science of surgery, and commitment to evidence-based surgical innovation; and Dr. Swaroop Gantela, Dr. Safia Rafeeq, and Linda McGraw for their time and assistance in manuscript and data preparation.

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Discussions

DR. QUAN-YANG DUH (SAN FRANCISCO, CALIFORNIA): In the 1990s, there were several nonrandomized studies showing no difference between the transabdominal approach (the so-called Gagner technique) versus the lateral or posterior retroperitoneal approach. Both were minimally invasive and both were significantly better than the traditional open adrenalectomy in terms of postoperative pain, complication and recovery time.

Because there were no outcome differences between the laparoscopic transabdominal approach and the posterior retroperitoneal approach, many of us who have tried both techniques settled on routinely using the transabdominal technique. The anatomy from the transabdominal approach was easier to learn and teach, and it seemed to work better for larger and potentially malignant tumors.

The posterior retroperitoneal approach, however, remained attractive since it has potential advantages for patients with extensive intra-abdominal adhesions and for those who need bilateral adrenalectomies.

Martin Walz made 2 modifications that significantly improved the posterior retroperitoneal technique. He routinely uses a very high insufflation pressure, to about 20 to 25 mm of mercury. This creates a larger and less bloody space for dissection. The other modification is to free the adrenal gland inferiorly first, dissecting it away from the kidney, leaving the adrenal gland hanging from its superior attachment. This makes the dissection of the adrenal vessels easier and safer.

I have 3 questions for you. First, do you find it harder to teach the posterior approach to the residents and fellows? In contrast to the transabdominal approach, the anatomy is less familiar to the general surgeons and can become confusing, somewhat like the preperitoneal inguinal hernia repair performed laparoscopically. How do you teach this technique?

Second, is there a size limitation for the posterior retroperitoneal approach, and is this different than for the transabdominal approach? In the earlier days of laparoscopic adrenalectomy, the MD Anderson group cautioned us not to do laparoscopic resection for adrenal tumors larger than 3 cm because of the potential for malignancy. With a median tumor size of 3.2 cm, obviously more than half of your tumors are larger than 3 cm. I noted that one was 9.2 cm. Has your thinking regarding the advisability of laparoscopic resection for larger adrenal tumors evolved? If you have a size criterion, what is it, and is it the same for the posterior approach as it is for the transabdominal approach?

My third question is more practical. What would you recommend for a thin patient with a 5-cm right adrenal pheochromocytoma? What about a nonfunctioning left adrenal tumor 5 cm in a patient with a BMI of 35?

DR. ANDREA FRILLING (ESSEN, GERMANY): The feasibility of retroperitoneoscopic adrenalectomy was first reported in 1993 by the Italian urologist Mandreassi. Following this initial experience, Walz from Germany adopted this technique broadly and applied it in nearly 600 patients with various adrenal tumors and paraganglioma. For a surgeon used to the laparoscopic approach to the adrenal gland, the retroperitoneoscopic technique might seem more challenging because of the limited space and fewer landmarks when exposing the gland from the posterior surface.

I would like to address the following issues:

Retroperitoneoscopic removal of the adrenal gland might be more demanding on the right side when compared with the left side, because of variations of the right adrenal vein with regard to the posterior hepatic veins as seen in up to 20% of patients. Have you been faced with any anatomic variants of the right adrenal vein in your patients?

In patients with bilateral pheochromocytoma partial adrenalectomy is recommended to minimize the postoperative dose of corticosteroids. Twenty of your patients had a pheochromocytoma. Were there any with bilateral disease among them, and if so, do you have any experience with retroperitoneoscopic subtotal removal of the adrenal gland?

And lastly, 15 of the patients in your series had adrenal metastases. How should we preoperatively rule out that a lesion within an adrenal gland is not a carcinoma? For endoscopic adrenalectomy, either via laparoscopic or retroperitoneoscopic approach, a discrimination between a metastasis and a primary carcinoma is crucial, because locoregional and port-side tumor seeding has been reported in several patients after endoscopic adrenalectomy for unrecognized adrenal carcinoma.

DR. RICHARD A. PRINZ (CHICAGO, ILLINOIS): The adrenal glands are tucked away in the retroperitoneum, and as a consequence surgeons have used a variety of ways to get to them. This was true in the open surgery era and is true currently in our laparoscopic era so one size does not fit all. I think it is a matter of selecting the right approach for the right patient for the right problem. You gave us some indications where this retroperitoneal approach may be preferable, such as bilateral disease, and previous abdominal surgery would prevent you from removing the adrenal transabdominally. I have used this approach and found that a patient's amount of retroperitoneal fat affected my ability to perform this operation with any facility. Thus, I think a patient with a great deal of retroperitoneal fat, should be approached with caution.

In regards to metastatic disease, I am quite concerned about using an approach where there is much more manipulation of the tumor and that does not provide options in case you find invasion into surrounding structures. Furthermore, it is desirable, with malignancy, to evaluate the liver and other potential intra-abdominal sites for metastases. I have used the transabdominal approach preferentially for these situations. What piqued my interest was your conversions. I would have been interested in seeing that conversion to an anterior approach in the operating room. Could you comment on the superior vena cava syndrome that you encountered, because I have not seen this with the transabdominal approach.

DR. PATRICIA K. DONAHOE (BOSTON, MASSACHUSETTS): We have a series of patients with congenital adrenal hyperplasia, some of whom become refractory to steroid replacement therapy, which is required for life. Adrenalectomy has been proposed for these patients or, potentially, for all patients with congenital adrenal hyperplasia since serial replacement for adrenal hypoplasia is less complex than steroid blockade of hyperandrogenemia.

Is this approach safe in children? How much pressure insufflation should be used? What is the youngest patient on which you have performed this operation?

DR. NANCY D. PERRIER (HOUSTON, TEXAS): In answer to the question, how do we teach this, I think this is a grand example of the overall diffuse problem that we see in our current era, regardless of whether we are doing adrenal surgery or doing other complex operations. This is a problem we see at our own institutions whether we are performing skin-sparing mastectomies, Whipple operations with venous reconstruction, or trisegmentectomies.

This is an operation that is complex and it is not for the one-time fellow who is straight out of general surgery residency and who is spending a month in our service. Furthermore, it is difficult to teach because it is a reorientation of the retroperitoneum. Becoming accustomed to the anatomy and identifying landmarks requires repetition. We do not feel this operation is for the general surgery training program designed for someone who may be doing one of these per year or one every 6 months.

We began our series as a group. The 3 of us learned it, and we performed the majority of operations in pairs as one of us ran the camera and another performed the operation.

We have now improved the procedure and we reserve teaching this operation to those who will use it as part of their career. It is an operation that our surgical endocrine fellows are learning as they have committed their careers to include adrenal disease.

The second question asked about the size limitation. We previously reported that when the diagnosis includes adrenocorticocarcinoma, which are usually large, a laparo-

scopic operation, in our belief, is not the procedure of choice. We retain that same philosophy.

During this series, there were 190 adrenalectomies performed at our institution, 89% of them by our group. That means that a large majority of open operations were performed. In all of these cases, the differential never included ACC either by radiographic criteria or size changes.

There were 3 patients who had tumors that were greater than 6 cm. The endocrine surgical literature refers to 6 cm because the incidence of malignancy is about 25% at this size. In this series, such patients received a preoperative benign diagnosis. One was an adenoma that hemorrhaged. The other was a testosterone-producing tumor that was part of a bilateral procedure, and the other was clearly benign in appearance but was resected because of pain reported by the patient. One patient in our series did have a tumor that on pathologic review turned out to be 9 cm. By radiographic imaging it was 5.9 preoperatively. We are comfortable using 6 cm as our size cut-off.

In answer to your last question, in our belief this would be the perfect approach in a thin patient with a 5-cm pheochromocytoma.

Your question asks about a patient with a BMI of 35. In our series, 44% of our patients had such BMIs. When we teach this procedure, the obese is not the case to start with, and this is what Dr. Walz recommends as well.

Regarding the anatomy of the right adrenal vein, we feel that the direct posterior approach is excellent. We have not recognized the anatomic variance that you describe. We identify the inferior border of the adrenal, and then moving medially and dissecting until we encounter the vein.

As far as subtotal resection in patients with bilateral pheochromocytomas, we do have a series of cortical-sparing adrenalectomies that we perform, and we perform those in the MEN-II patients that we see with bilateral pheochromocytomas. It is our general principle that for unilateral pheochromocytomas we perform a total adrenalectomy and when the patient has a bilateral lesion or secondary lesion, a subtotal resection is performed.

We have an experience with that in an open series. We do not have any experience in this series of performing a subtotal resection. In our open series, we had functional adrenal remnants that did not require steroid supplementation in one-third of the population, and that was with good exposure and a good open field. Thus, I think we would be very cautious and worry about leaving a functional remnant, particularly in a child, with MEN by this approach. We just do not have the experience. We would probably do the open operation in that case.

Dr. Prinz, your point about patient selection is excellent, and that is the importance of this operation. This operation is more difficult in obese patients as we mentioned previously. We found a trend in the latter half of the series, in thin patients, as our operative time was considerably shorter

than in the obese patients. We do not feel that obesity is a contraindication, but understanding the anatomy and patient positioning is critical, particularly in flexing the hips and allowing the intra-abdominal wall to hang freely, which is not always easy in a patient with a protuberant belly.

The last question regarding applicability of this technique in children, we had a child in the series that was 11 years old, but we do not have a large experience with children. However, this would be an ideal operation. I defer to Dr. Walz's experience with CO₂ insufflation and high pressures. The data are sound for adults that there is no decreasing venous return despite the high insufflation pressure. I would assume it would not be different in children, but I cannot speak to that first-hand. Nevertheless, in our one 11-year-old child, it was a straightforward operation.

To comment on the vena cava syndrome and to the 3 open conversions, one was to an open anterior approach. This was early in the series, and there was bleeding into the

hepatic vein. Because of the concern of intracorporeal suturing we decided it was best to stop, close and turn the patient. There were no serious complications and no significant hemorrhage.

As for the other 2 conversions, one was to a posterior approach because of a pheochromocytoma that began to show blood pressure instability, and in the sake of time, we felt it best to open posteriorly and remove the gland. This was in the first half of the series. The third open operation converted to the posterior approach was due to failure to progress. The metastases are often more difficult because of the adhesions to the kidney and surrounding fat.

Finally, regarding metastatic disease, in no case were we ever suspicious that these were adrenal corticocarcinomas. The diagnosis was confirmed preoperatively with an abdominal CT-guided fine needle aspiration. The majority of the metastasis was from the lung primary, but we appreciated breast, melanoma, and a thyroid metastasis to the adrenal gland.