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ORIGINAL ARTICLE

Management of adrenal incidentaloma by laparoscopic transperitoneal anterior and submesocolic approach

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Abstract
Purpose Laparoscopic adrenalectomy (LA) is becoming the main approach for incidentally discovered adrenal masses (adrenal incidentaloma (AI)). The aim of this study was to evaluate the results of LA with a transperitoneal anterior approach for right adrenal lesions and either a transperitoneal anterior or transperitoneal anterior submesocolic approach for the left-sided lesions.
Methods The study is a retrospective analysis of prospectively collected data. From January 1994 to December 2012, 393 patients underwent LA, 117 of these for an AI. Sixty-seven (57.26 %) and 50 (42.73 %) patients underwent right and left adrenalectomy, respectively. The transperitoneal anterior approach was used in all 67 patients with right lesions (57.26 %) (group A) and in 13 patients with left-sided lesions (11.11 %) (group B). The transperitoneal anterior submesocolic approach was used in the remaining 37 left-sided lesions (31.62 %) (group C).
Results Mean operative time in groups A, B, and C was 104.6 min (range 35–255), 148.9 min (range 80–210), and 82.7 min (range 45–230), respectively. One right and one left anterior LA (1.7 %) were converted to open surgery. There were one major and one minor complications (1.7 %). The mean lesion size was 4.73 cm (range 1–10 cm). Mean hospital stay was 3.6 days.
Conclusions With adequate experience, LA with a transperitoneal anterior approach for AI is a safe and effective procedure. Early control of the adrenal vein with minimal gland manipulation and limited surgical dissection are its major advantages. In case of left LA, the submesocolic approach reduces the operative time significantly.

Keywords Adrenal incidentaloma · Adrenal tumors · Laparoscopic adrenalectomy · Transperitoneal anterior approach · Submesocolic approach

Introduction

Adrenal "incidentaloma" (AI) is a previously unknown adrenal mass which is incidentally discovered during the diagnostic workup for other clinical conditions not immediately related to disorders of the adrenal glands [1]. In the last two decades, the introduction and widespread use of high-definition imaging technologies, such as magnetic resonance (MRI) or computed tomography imaging (CT) and ultrasound (US) have increased the discovery of AIs [2]. The incidental finding of an adrenal gland mass involves planning of a series of specific exams in order to define the malignant potential and any potential hormonal secretion [3]. The management of AIs is complex. In most cases, conservative treatment is justified because of their slow tendency to grow and hormonal inactivity at prolonged follow-up [4]. Surgical treatment of AI is currently indicated for those lesions having clinical expression, even when mild or subclinical [5, 6], as well as for lesions measuring more than 4 cm in diameter, in which the

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malignancy rate or the progress towards it, are not negligible (6 % of adrenal cortical carcinoma in lesions ranging from 4.1 to 6 cm and 25 % in lesions greater than 6 cm) [4, 7]. This is more important considering the recently reported inaccuracy of conventional imaging techniques in evaluating the size or growth rate, with an 18–20 % underestimation rate by CT and MRI for adrenal tumors larger than 3 cm in diameter [8, 9]. On the other hand, laparoscopic adrenalectomy (LA) provides early and definitive diagnosis and treatment, avoiding the cost of traditional long-term follow-up that would be required by the conservative management of these tumors.

In the past, the traditional open approach for adrenalectomy was difficult due to the deep anatomical location of the gland, and it was associated with up to 39 % morbidity rate and prolonged hospital stay [10–12]. In 1992, Gagner first described transperitoneal LA with the patient in a lateral decubitus position [13]. Other alternatives that were described are the retroperitoneal approach with the patient in a prone position or the transperitoneal anterior approach with patient supine [14–16]. Several studies have confirmed the safety and efficacy of these techniques, so that minimally invasive adrenalectomy is now considered the treatment of choice for both benign and malignant lesions [17–19].

The aim of this study was to evaluate the results of LA by the transperitoneal anterior approach in the treatment of AIs.

Materials and methods

This study is a retrospective analysis of prospectively collected data. From January 1994 to December 2012, out of 393 patients who underwent LA in two centers (Department of General Surgery, Surgical Specialties and Organ Transplantation, "Paride Stefanini", "Sapienza", University of Rome, and Department of General Surgery, Università Politecnica delle Marche, Ancona, Italy) according to the same treatment protocol and identical surgical approach, 117 patients were referred with a diagnosis of AI (49 males, and 68 females, mean age 56.23 ± 13.48 years, age range 17–81 years). Data as age, body mass index (BMI), gender, lesion size, lesion side, symptoms, previous abdominal surgery, approach, operative time, associated procedures, conversions, postoperative complications, blood transfusions, hospital stay, definitive histology, and resumption of liquid diet were stored and processed by means of the Microsoft Excel program (Microsoft Corporation, Redmond, WA, USA). American Society of Anaesthesiologists (ASA) patients' classification grade and comorbidities have not been stored. No symptoms from adrenal gland disease were recorded in 108 (92.3 %) of these cases. In nine patients (7.7 %), the following conditions were diagnosed pre-operatively: hypertension (3), subclinical Cushing's syndrome (3), right upper quadrant pain (1), adrenogenital syndrome (1), and cardiac arrhythmia (1). In order to establish the adrenal functional status, all patients underwent complete hormonal evaluation. Diurnal serum cortisol rhythm, 24-h urinary free cortisol (UFC), plasma adrenocorticotropic hormone (ACTH), dehydroepiandrosterone (DHEAS), 17-hydroxyprogesterone (17-OHP), testosterone, androstenedione, supine and upright renin activity and aldosterone, and 24-h urinary catecholamine levels (epinephrine, norepinephrine, and metanephrine) were evaluated. Hormonal dynamic tests included an overnight 1-mg dexamethasone suppression test (DST). The diagnosis of adrenal Cushing's syndrome, aldosterone-producing adenoma, and pheochromocytoma was based on elevated UFC, abnormal serum cortisol 24-h rhythm, inadequate cortisol suppression after 1-mg dexamethasone, low and/or suppressed plasma ACTH, high plasma aldosterone plasma renin activity (PRA) ratio (>40), unsuppressed aldosterone after sodium load, and elevated urinary metanephrines. In the absence of specific signs and/or symptoms of autonomous hormone secretion, abnormal hypothalamus-pituitary-adrenal axis tests, and an imaging compatible with adrenocortical lesion, a diagnosis of non-functioning adenoma was made. All patients were studied with CT scan and MRI. An attenuation value of 1O or less Hounsfield Units (HU) on unenhanced CT scan was considered as suggestive of benign adrenocortical adenoma [20]. An absolute contrast washout of >60 % and a relative contrast washout of >40 % characterize an adenoma, with 98 % sensitivity and 92 % specificity rates, respectively [21, 22].

At MRI, adrenocortical adenomas appear homogeneous in all sequences, with mild gadolinium enhancement. They have low or equal signal intensity to the liver on T2-weighted images and may appear of lower signal intensity than the rest of the adrenal gland [20]. Using MRI, chemical shift imaging can be done to identify fat within the lesion as decreased signal intensity relative to normal tissue.

For carcinomas, the attenuation on unenhanced studies is higher than 10 HU on CT scan [23]. On contrast-enhanced studies, carcinomas enhance avidly due to their vascularity, and the enhancement pattern may be homogeneous, unless there is central necrosis [23, 24]. The relative percentage washout of carcinomas is <40 % [25]. On MRI, adrenal carcinomas are noted for heterogeneity on T1-weighted images, with intermediate to high signal intensity [26]. Heterogeneity is also noted on T2-weighted images due to hemorrhage and/or necrosis [26].

Based on these criteria, 117 patients with adrenal lesions greater than 4 cm in diameter or with smaller lesions but having an imaging pattern suspicious for malignancy or with subclinically secreting tumors underwent LA. In the first part of the authors' experience, left adrenalectomy was performed preferably by the transperitoneal anterior approach in case of larger tumors, but after completing the learning curve, the submesocolic approach was routinely employed in every case independently from tumor size. Technical difficulties were

evaluated on the basis of conversion rate and procedure duration. Informed consent was obtained from all individual participants included in the study. Complications were graded according to the Clavien classification [27].

Surgical techniques

Surgical techniques for right and left anterior LA and for left submesocolic LA have been previously described [28–32]. Briefly, they are described below.

Right adrenalectomy The patient is supine on the operative table. After the induction of pneumoperitoneum, the first 12-mm optical trocar (n. 1) is inserted in paramedian position, above the transverse umbilical line. The second 12-mm trocar (n. 2) is placed under vision 2 cm left of the midline below the left costal arch. The third (n. 3) and fourth (n. 4) trocars are then inserted, one at the junction between the right anterior axillary line and the transverse umbilical line and the other along the right midaxillary line, respectively (Fig. 1). The optic is introduced from trocar n. 3 while trocars n. 1 and 4 are the operating ones. Adhesions between the gallbladder, greater omentum, and transverse colon are divided and the liver is raised with a retractor (Endo Retract II™, Covidien, Mansfield, MA, USA, or Endo Paddle Retract™, Covidien, Mansfield, MA, USA) introduced from trocar n. 2, in order to expose Morrison's pouch. The right margin of the inferior vena cava above the duodenum is identified, and the posterior parietal peritoneum is divided longitudinally along this margin, extending the incision cranially towards the diaphragm where the adrenal gland may be distinguished from the retroperitoneal fat due to its typical yellow ocher color. The retrocaval arterioles along the medial border of the adrenal gland are then divided with a vessel sealing device (LigaSure™ tissue fusion, Covidien, Mansfield, MA, USA) or ultrasonic (Ultracision, Harmonic Scalpel, Ethicon Endo Surgery, Cincinnati, OH, USA) instrumentation. The right adrenal vein is identified by blunt dissection, avoiding any manipulation of the gland that could lead to an increase in circulating hormones, and it is divided between titanium clips (AcuClip, Tyco/Healtcare, Norwalk, CT, USA). Finally, the gland is mobilized using a radiofrequency (LigaSure™ tissue fusion, Covidien, Mansfield, Massachusetts, USA) or ultrasonic (Ultracision, Harmonic Scalpel, Ethicon Endo Surgery, Cincinnati, OH, USA) device, and it is then removed from the abdominal cavity inside a specimen retrieval bag, after enlarging one of the trocar incisions.

Left adrenalectomy—transperitoneal anterior approach After the induction of pneumoperitomeum, the first 12-mm optical trocar (n. 1) is inserted to the left of the midline above the umbilicus (Fig. 2). The second 12-mm trocar (n. 2) is inserted under vision on the right midclavicular line below

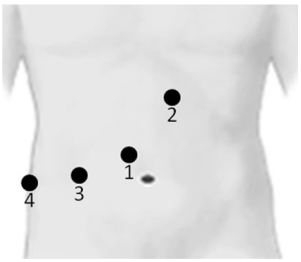

Fig. 1 Trocar positions during transperitoneal right adrenalectomy. The surgeon and the first assistant stand on the right of the patient; the second assistant stands on the left

the right costal arch. The third and fourth trocars are placed one on the left midclavicular line along the transverse umbilical line (n. 3) and one on the left anterior axillary line (n. 4), respectively. The left parietocolic peritoneum is divided, extending the incision caudally along the parietocolic reflection towards the sigmoid colon. After division of the splenocolic ligament, the splenic flexure and descending colon are mobilized medially by blunt dissection. Once the lower edge of the pancreatic tail is identified, Gerota's fascia is opened to expose the left adrenal gland. The left adrenal vein is then identified by blunt dissection at its confluence with the left renal vein. The left adrenal vein is closed with titanium clips (AcuClip, Tyco/Healtcare, Norwalk, CT, USA) and divided. This is followed by division of the subdiaphragmatic arterial branches which are medial and cranial to the adrenal gland. Again, dissection is performed either with a radiofrequency (LigaSure™ tissue fusion, Covidien, Mansfield, MA, USA) or ultrasonic (Ultracision, Harmonic Scalpel, Ethicon Endo Surgery, Cincinnati, OH, USA) device, according to the surgeon's preference. Monopolar electrocautery is used selectively for hemostasis. After the release of the gland from the adrenal space, this is removed inside an extraction bag. The residual adrenal space is then filled with hemostatic material (Floseal, Baxter Healtcare Corporation, Deerfield, IL, USA) and a drainage is left in place.

Left adrenalectomy—transperitoneal anterior submesocolic approach This approach is alternative to the transperitoneal anterior one with left colonic flexure

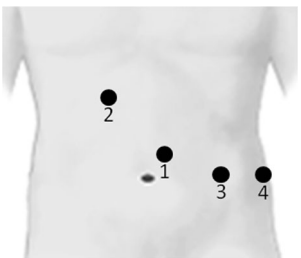

Fig. 2 Trocar positions during left transperitoneal adrenalectomy. The surgeon and the first assistant stand on the left of the patient while the second assistant stands on the right

mobilization described above, but it entails the same trocars' position (Fig. 2). The optic is introduced from trocar n. 3, while trocars 1 and 4 are the operating ones. Again, with the operating table in slight anti-Trendelenburg position and a lateral tilt with left side up, the transverse mesocolon is raised by the assistant with atraumatic forceps introduced from trocar n. 2, to expose the first jejunal loop at the ligament of Treitz and to identify the inferior mesenteric vein after displacing the jejunum on the patient's right side. The posterior peritoneum is opened at the insertion of the transverse mesocolon on the lower edge of the pancreas, between the first jejunal loop and the arch of the inferior mesenteric vein or immediately lateral to the latter vessel, according to its distance from the jejunum. After the identification of Toldt's fascia, the dissection then proceeds posteriorly along this plane in the retropancreatic space, after raising the body of the pancreas with an atraumatic instrument held by the surgeon's left hand. The splenic vein is usually identified at this point on the postero-inferior aspect of the pancreas. Next, Gerota's fascia is opened to identify the superior margin of the left renal vein. This is followed medially until its junction with the inferior adrenal vein is identified. The left adrenal vein is then carefully prepared and divided between clips (AcuClip, Tyco/Healtcare, Norwalk, CT, USA). Again, it is worth noting that no manipulation of the left adrenal gland has yet occurred prior to the division of the main adrenal vein because the gland is located cranially to this vessel.

Statistical analysis

Statistical analysis was done using the *t* test and data are presented as mean ± standard deviation. A probability (*p*) value lower than 0.05 was considered statistically significant. Fisher's exact test was used to evaluate the difference within groups.

Results

In 67 out of 117 cases, the AI (57.26 %) was located on the right and in 50 (42.74 %) cases, it was on the left side. The transperitoneal approach anterior was used in 67 patients with right-sided lesions (57.26 %) (group A) and in 13 (11.1 %) with left-sided lesions (group B). A transperitoneal anterior submesocolic approach was used in 37 left LA cases (31.63 %) (group C). There were no significant differences in patients' characteristics (Table 1). Mean operative time in groups A, B, and C was 104.6 ± 44.9 min (range 35–255), 148.9 ± 44.4 min (range 80–210), and 82.7 ± 34.92 min (range 45–230), respectively. There was a statistically significant difference in mean operative time between groups B and C ($p = 0.0001$). Operative time stratified according to the tumor size is shown in Table 2. In two patients (1.7 %), the procedure was converted to open surgery due to the right adrenal gland encased into the liver parenchyma (1) and firm adhesions of the left adrenal gland to the tail of the pancreas (1) in a left LA with anterior approach. Postoperative complications (grades II and III-b respectively) were observed in two cases (1.7 %): left adrenal space abscess (1) treated conservatively and hemoperitoneum (1) after right LA treated with reoperation by laparoscopy. Postoperative blood transfusions were required in two patients (1.7 %). Eight patients (6.8 %) underwent concurrent surgical procedures: cholecystectomy (6), left ovariectomy (1), and right renal cyst deroofing (1) (Table 3). The mean size of adrenal tumors was 4.73 ± 1.9 cm (range 1–10). Patients' mobilization and resumption of liquid diet occurred on the first postoperative day. Mean hospital stay was 3.6 ± 1.89 days (range 2–12) and mortality was nil. Definitive histology was as follows: adrenocortical adenoma (80), myelolipoma (17), nodular hyperplasia (10), adrenocortical carcinoma (4, T2N0M0), cysts (2), chromaffin cell tumors consistent with silent pheochromocytoma (2), hemorrhagic pseudocyst (1), and adrenal hematoma (1). The two patients in whom histology revealed pheochromocytoma did not suffer hypertension or cardiac rhythm abnormalities during surgery.

Discussion

This study aimed at evaluating the results of the laparoscopic anterior approach and particularly of the submesocolic approach for left-sided lesions, in the management of AI. The results confirm the safety and efficacy of the laparoscopic anterior approach. In case of left LA, the submesocolic approach had the additional benefit of a significant reduction in the operative time, as compared to the traditional anterior approach, and compares favorably also with the operative time after the lateral and retroperitoneal approaches reported in the literature (Table 4) [11, 12, 14–18, 33–39].

Laparoscopic adrenalectomy is the gold standard for the surgical treatment of adrenal lesions (Conn's syndrome, Cushing's disease, pheochromocytoma, incidentalomas, and adrenal metastases) [29, 30, 40]. Laparoscopic surgery is associated with minimal or no postoperative pain. A liquid diet is tolerated on the first postoperative day and the hospital stay is short [14, 15, 30, 31, 34–37]. Several laparoscopic approaches for adrenalectomy have been proposed in the literature. After the first laparoscopic adrenalectomy with lateral approach proposed by Gagner in 1992 [13], the retroperitoneal [33–35, 41] and anterior approaches [30, 31, 38–40] have also been reported. The authors favor the latter, as previously reported [28–31]. The transperitoneal anterior submesocolic approach to the left adrenal gland was first proposed by Delbet in 1912 [42]. The authors have originally proposed it laparoscopically in 2005 [28], after having demonstrated that

Table 1 Patients' characteristics

	Group A $n=67$	Group B $n=13$	Group C $n=37$	p value
Sex ratio (M:F)	31:36	4:9	14:23	Group A vs B, 0.3704 Group A vs C, 0.5355 Group B vs C, 0.7460
Mean age ± SD, years (range)	56.71 ± 12.66 (17–78)	60.23 ± 14.4 (29–79)	53.90 ± 14.13 (26–81)	Group A vs B, 0.3760 Group A vs C, 0.3159 Group B vs C, 0.1779
BMI ± SD, Kg/m^2 (range)	27.59 ± 3.99 (18–45)	27.05 ± 4.45 (18–34)	26.29 ± 6.71 (21–45)	Group A vs B, 0.9861 Group A vs C, 0.3615 Group B vs C, 0.6575
Previous abdominal surgery, *n* (%)	13 (19.4)	2 (15.3)	10 (27.02)	Group A vs B, 1.0000 Group A vs C, 0.4602 Group B vs C, 0.4795

BMI body mass index, *A* transperitoneal anterior right adrenal approach. *B* transperitoneal anterior left adrenal approach, *C* transperitoneal anterior submesocolic left adrenal approach. *Vs* versus

this approach provided a more direct access to the left gland, with a decrease in the extent of anatomical dissection and decreased operative time. Due to the experience gained by the authors with the transperitoneal anterior approach for left-sided lesions, the learning curve and the transition to the submesocolic approach, which at the very beginning was used for smaller lesions, was brief, and made it possible to employ the submesocolic approach in each case with no more specific inclusion criteria.

Worldwide, the lateral approach is mostly performed, followed by the retroperitoneal and then by the anterior approaches [43]. The proponents of the lateral approach advocate several advantages to explain this choice such as the excellent exposure of the operative field which remains free from blood collections that are drained by gravity [31, 36, 44]. In the authors' opinion, however, this approach does not provide early ligation of the adrenal vein prior to any gland manipulation, which the authors believe to be important so as to avoid pressure instability in case of secreting adenomas, and particularly of pheochromocytoma, and which is also oncologically correct [30, 38].

According to its proponents, the retroperitoneal approach also has several advantages such as the absence of any intraperitoneal dissection, no bowel manipulation, and less postoperative pain [36], and it is preferred in obese patients or after previous intraperitoneal surgery [45]. In the authors' opinion, however, this approach does not allow straight forward conversion to open surgery in case of extensive bleeding. In case

Table 2 Mean operative time based on tumor size and type of approach

	Tumor size (cm)			
Mean operative time ± SD, minutes (range) according to the type of the approach	0–3	3–6	6–10	p value
Group A, n. of patients	103.9 ± 55.05 (35–255) 17	101.6 ± 44.17 (55–240) 39	114.3 ± 7.69 (70–170) 11	Group 0–3 vs 3–6, 0.8789 Group 0–3 vs 6–10, 0.6437 Group 3–6 vs 6–10, 0.4589
Group B, n. of patients	156.6 ± 68.06 (80–210) 4	133.3 ± 33.11 (100–180) 8	100 1	Group 0–3 vs 3–6, 0.4955 Group 0–3 vs 6–10, n.c. Group 3–6 vs 6–10, n.c.
Group C, n. of patients	73.1 ± 24.19 (50–120) 9	84.2 ± 25.88 (45–140) 20	90.7 ± 62.47 (50–230) 8	Group 0–3 vs 3–6, 0.3108 Group 0–3 vs 6–10, 0.4732 Group 3–6 vs 6–10, 0.7054
p value	Group A vs B, 0.1662 Group A vs C, 0.1518 Group B vs C, *0.0108*	Group A vs B, 0.1031 Group A vs C, 0.1227 Group B vs C, *0.0009*	Group A vs B, n.c. Group A vs C, 0.3903 Group B vs C, n.c.	

Statistically significant differences are in italics

A transperitoneal anterior right adrenal approach, *B* transperitoneal anterior left adrenal approach, *C* transperitoneal anterior submesocolic left adrenal approach, *Vs* versus, *n.c.* not computable

Table 3 Results

	Group A $n=67$	Group B $n=13$	Group C $n=37$	p value
Conversion rate, n (%)	1 (1.4)	1 (7.6)	–	Group A vs B, 0.3003 Group A vs C, 0.10000 Group B vs C, 0.2600
Complications, n (%, Clavien's classification, class)	1 (1.4, III-b)	1 (7.6, II)	–	Group A vs B, 0.3003 Group A vs C, 0.10000 Group B vs C, 0.2600
Blood transfusions in patients, n (%)	2 (8.3)	–	–	Group A vs B, 0.10000 Group A vs C, 0.10000 Group B vs C, 0.10000
Associated procedures, n (%)	5 (7.4)	2 (15.3)	1 (2.7)	Group A vs B, 0.3179 Group A vs C, 0.4183 Group B vs C, 0.1618
Mean hospital stay ± SD, days (range)	3.34 ± 1.88 (2–12)	4.7 ± 1.41 (2–6)	3.85 ± 1.94 (2–11)	Group A vs B, *0.0376* Group A vs C, 0.2460 Group B vs C, 0.2079

Statistically significant differences are in italics

A transperitoneal anterior right adrenal approach, *B* transperitoneal left adrenal anterior approach, *C* transperitoneal anterior submesocolic left adrenal approach, *Vs* versus

of pheochromocytoma, the patients' position on the operative table may itself be a cause of pressure instability [37]. Moreover, even the proponents of this method consider a large tumor size or the presence of other intra-abdominal pathology as contraindications for the retroperitoneal approach [33]. In fact, both the lateral and the retroperitoneal routes do not allow to perform associated surgical procedures [30, 46]. For the lateral approach, exploration of the contralateral gland is not possible without repositioning the patient [30, 46], which increases the operative time.

The anterior approach on the right and the submesocolic approach on the left provide for immediate control of the main adrenal vein prior to any gland manipulation; rapid conversion to open surgery is possible, should it be required, and

Table 4 Patient series reported in the literature

Authors	No. of patients	Approach	Mean age (years)	Mean operative time (minutes)	Conversion rate (%)	Complication rate (%)	Hospital stay (days)
Hazzan [11]	24	Lateral	45.4	188	7	16	4
Vargas [12]	20	Lateral	47	193	10	10	3.1
Bonjer [14]	79	Retroperitoneal	50	114	6.3	10.1	2
Gagner [15]	100	Lateral	46	130	3	12	2.5
Salomon [16]	21	Retroperitoneal	46	116	0	19	3.4
Lang [15]	56	Retroperitoneal	36.2	52	1.8	1.7	5.2
Janetschek [18]	19	Lateral	49.7	150	0	16	7
Walz [33]	560	Retroperitoneal	49.2	67	1.7	11.8	–
Dickson [34]	23 23	Lateral Retroperitoneal	42 47	145 100	4.3 13	8.7 13	3.1 1.9
Fernandez-Cruz [35]	16 14	Lateral Retroperitoneal	36 47	89 105	12.5 14.2	12.5 0	3 2.75
Mohammadi-Fallah [36]	11 12	Lateral Retroperitoneal	43 42	129 128	0 8.3	9.1 8.3	3.6 3.1
Cabalag [37]	13 10	Lateral Retroperitoneal	47 61	105 90	0 0	30.7 10	2 1
Matsuda [38]	75	Anterior	–	221	0	3.9	10.2
Linos [39]	18	Anterior	48.7	116	5.5	0	2.3

associated procedures may be performed without the need to reposition the patient. Moreover, for right-sided lesions, early ligation and division of the right adrenal vein after preparation of the medial margin of the gland increases the distance of the gland from the inferior cava vein and facilitates subsequent mobilization of the gland [30, 31]. In case of left-sided lesions, the transperitoneal anterior submesocolic approach does not require mobilization of the left colonic flexure or of the spleno-pancreatic complex to gain access to the adrenal gland, with operative time reduction as compared to the transperitoneal anterior and lateral approaches [47].

Incidentalomas are becoming increasingly frequent due to the wider use of US, CT scan, and MRI, and are currently found in approximately 4–6 % of the population [48]. About 20 % of adrenal incidentalomas are secreting tumors [1], mostly cortisol, or its precursor, with a low secretory activity. Whenever an unexpected adrenal mass is found, a clinical and laboratory-specific evaluation should be carried out, in order to exclude malignancy or hypersecreting hormonal activity [4]. Laparoscopic adrenalectomy in cases of pheochromocytoma, pre-Cushing, and aldosteronism might avoid the long-lasting effects from the altered hormonal status [28–32, 49]. Recent studies reveal that incidentalomas can be frequently associated with very mild cortisol autonomous secretion that is clinically silent, if not dynamically tested, but still capable to increase cardiovascular mortality [50]. For this reason, hormonal testing is always recommended and, when abnormal, surgical removal should be considered [5, 6]. Adrenal carcinoma is a rare entity in otherwise healthy patients. However, in a young subject with previous carcinoma elsewhere, or with a secreting adrenal mass, or an adrenal non-secreting incidental lesion of more than 4 cm in diameter, the risk of adrenal carcinoma rises up to 20 % [51, 52]. Adrenal tumors are often incidentally detected with abdominal ultrasound (96 and 100 % sensitivity rates are reported for tumors smaller or larger than 2 cm, respectively) [53]. More accurate and expensive imaging technologies, such as CT scan and particularly MRI, are the second-line diagnostic procedures [20–26] which may casually detect adrenal lesions but also provide valuable details concerning their possible malignancy [51]. CT scan has a 95 % accuracy rate in evaluating adrenal lesions, finding cystic or solid masses of 5 mm in size [51]; however, MRI offers more data. Moreover, CT scan reveals peculiarities of malignancy, such as the lesion margins or intralesional-calcified areas [51]. MRI is crucial in characterizing a lesion as an adenoma, based on the ratio of decreased relative signal intensity from in phase to opposed phase image, typical of those lesions containing fat and lipid.

Scintigraphy with ^{131}I-6 beta-norcholesterol (NP59) or with ^{131}I metabenzilguanidine (MIBG) is used to characterize adrenocortical and adrenomedullary lesions, respectively [26, 51]. Computed tomography or MRI data together with scintigraphic results may clarify the pre-operative suspicion of malignancy [20–22].

In a recent meta-analysis on retroperitoneal versus lateral LA, conversion rates of 6 and 4 % and complications rates of 8 and 6 %, respectively, were reported [54]. These are not significantly different from the present series. The overall mean operative time, ranging in this series between 35 and 255 min, is somewhat lower as compared to the lateral (77–423 min) and the retroperitoneal approaches (75–300 min) reported in the literature [54]. In the present series, the greatest advantage in terms of reduced operative time was observed with the submesocolic approach for left LA. This is less evident with the right and left anterior approach, although the sample size of the latter is too small to draw definitive conclusions.

The limitations of this study are its retrospective nature and the fact that the better results with the submesocolic approach than with the anterior approach for left LA may have been influenced by the authors' increased experience. A randomized clinical trial, comparing the anterior approach with the submesocolic approach, would be required for more objective results.

Conclusion

LA with transperitoneal anterior and submesocolic approaches has proven to be safe and effective, and it is in line with the most recent literature [54]. Early ligation of the adrenal vein is the most important technical feature of this procedure in every type of lesion, to avoid release of catecholamines in case of pheochromocytoma, of hormones in case of cortical adenoma, or of neoplastic cells in case of adrenal carcinoma or metastasis.

Authors' contributions Alessandro M. Paganini, Mario Guerrieri, Andrea M. Isidori, Franco Iafrate, Giancarlo D'Ambrosio, Giovanni Lezoche, and Emanuele Lezoche contributed to the study conception and design, analysis and interpretation of data, and drafting and critical revision of the manuscript. Andrea Balla and Silvia Quaresima contributed to the study conception and design, acquisition of data, analysis and interpretation of data, and drafting and critical revision of the manuscript.

Compliance with ethical standards

Conflicts of interest The authors declare that they have no conflicts of interest.

Ethical approval All procedures performed in this study involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. For this type of study, formal consent is not required.

Informed consent Informed consent was obtained from all individual participants included in the study.

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