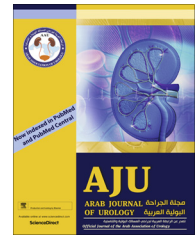




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ORIGINAL ARTICLE

Contemporary use of ultrasonic versus standard electro-surgical dissection in laparoscopic nephrectomy: Safety, efficacy and cost



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KEYWORDS

Ultrasonic scalpel;
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Laparoscopic nephrectomy;
Cost

ABBREVIATIONS

ASA, American Society of Anesthesiologists;
BMI, body mass index;

Abstract Objective: To assess the safety, efficacy and cost-effectiveness of ultrasonic dissection (USD) compared with standard monopolar electro-surgery (ES) in laparoscopic nephrectomy (LN).

Patients and methods: Retrospective analysis of patients' records who underwent elective LN was performed. Patients were divided in to two groups: USD and ES groups depending on the energy source used during LN. The preoperative (demographics, indication for surgery), intraoperative (conversion to open surgery, operative time, estimated blood loss [EBL], complications), and postoperative (morbidity/mortality, volume of drainage, hospital stay, cost) data were collected and analysed.

Results: Between February 2004 and February 2008, 136 patients were included. The indications for nephrectomy were: inflammatory (51 patients), non-inflammatory (64), and tumours (21). The two groups were similar for preoperative data. The conversion rate to open surgery (12.5%) and mean operative time did not differ significantly between the groups. However, intraoperative mean EBL was

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EBL, estimated blood loss;
ES, electrosurgery;
INR, Indian Rupee;
LN, laparoscopic nephrectomy;
USD, ultrasonic dissection

significantly less with USD, at 140.8 mL vs 182.6 mL for ES. There were no differences in postoperative parameters and morbidity. USD was significantly more expensive than ES (59 000 vs 26 000 Indian Rupees).

Conclusions: ES is a safe and feasible tool like USD in LN when used with caution. USD facilitates completion of difficult cases and reduces intraoperative blood loss. However, the majority of LNs can be completed safely with ES. ES is sturdy and cheap; therefore, selective use of USD appears to be the most cost-effective policy in the developing world.

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Introduction

Clayman et al. [1] introduced laparoscopic nephrectomy (LN) in 1991. During the past two decades, the application of laparoscopic renal surgery has seen tremendous growth, and this has thus created an increased demand for operative techniques, instruments, and their applications. A key factor in laparoscopic surgery is the use of techniques that permit safe dissection of the tissues with minimal collateral damage and adequate haemostasis. Dissection, coagulation, and division of the tissue are integral part of LN, which presents technical and haemostatic challenges. Electrosurgery (ES), although according to a survey of the American College of Surgeons [2], is the most commonly used tool for tissue dissection and coagulation in open surgeries, has shown some complications and limits related to its use in laparoscopy [3–4]. The complications attributed to ES in laparoscopy are often unrecognised and can cause significant morbidity and mortality [5]. The search for a safer energy source has resulted in the use of high-frequency ultrasound energy [6]. This source has also been adapted successfully for laparoscopy in the form of an ultrasonic dissector (Harmonic Scalpel, Ultracision, Ethicon Endosurgery Inc., Cincinnati, OH, USA) [7]. Several authors have reported the advantages of ultrasonic dissection (USD) for different laparoscopic abdominal operations [8–11]. Although USD is being widely used and is replacing conventional ES as the preferred tool for dissection in laparoscopic surgeries, it significantly increases the cost of the operation due to consumption of costly disposable instruments [12]. The cost of disposable instruments is a major determinant of the total cost of operation in the developing world, and is an important disincentive for laparoscopy in comparison to the open operations [13,14]. Fiscal responsibility is mandatory in the current healthcare environment, particularly in developing countries, where it is either public funded or paid by patients themselves due to a lack of health insurance. The aim of this retrospective study was to compare the safety, efficacy and the cost-effectiveness of USD compared with standard

ES in LN done by a single surgeon at a single tertiary care centre in India.

Patients and methods

We retrospectively reviewed the records of patients undergoing LN. For study purposes, patients were divided in two groups: in the first, the dissection was conducted by monopolar ES using either scissors or hook (ES group); while ultrasonically activated shears were used for dissection in the second group (USD group). Bipolar coagulation was used in both groups when deemed necessary. During the study period, the ultrasound generator used was Ultracision (Ethicon Endo-Surgery Inc.), and electro-dissector was ForceFx (Valley Lab, Pfizer Inc. USA). The protocols for anaesthesia, and preoperative and postoperative management, were uniform in the two groups. All patients with active infection and sepsis were treated preoperatively with broad-spectrum antibiotics and percutaneous drainage was implemented when deemed necessary. For preoperative bowel preparation polyethylene glycol solution was used. Intravenous antibiotics (amoxicillin clavulanic acid) were administered prior to incision and continued postoperatively until discharge from hospital. Low-molecular-weight heparin was used for deep venous thrombosis prophylaxis. Tramadol ensured postoperative analgesia during the first 48 h, and thereafter by oral non-steroidal analgesics or tramadol/paracetamol was used at patient's request depending on the serum creatinine level.

Surgical technique

All operations were performed by a single surgeon (N.K.A.) transperitoneally, using a previously described technique [13]. Briefly, the open access was obtained and pneumoperitoneum was created, two secondary ports (all metal) were placed and depending upon the requirement of retraction the fourth port was used. The bowel was reflected, and the ureter was dissected and used as a handle to reach the hilum. The hilar

vessels were circumferentially cleaned by blunt and sharp dissection, and were clipped either by Hem-o-lok clips (for renal artery and vein) or Liga clips (for other small vessels). The remaining attachments were taken down. The specimen was extracted via a small muscle-splitting Pfannenstiel incision.

In the ES group, monopolar ES was used for dissection and coagulation with a setting of 35 W cutting and 30 W coagulation. A reusable hook probe or scissors were used for cutting and fine dissection, and for haemostasis the laparoscopic grasper was used. All reusable hand instruments were used and the reusable hook cautery was replaced after every 50 cases or if damage to the insulation was detected, whichever occurred earlier. In the USD group, Ultracision was used for both cutting and coagulation at the maximum power settings. The 5-mm disposable ultrasonic scissors were used for cutting and coagulation.

Outcome measures

The preoperative data including age, gender, body mass index (BMI), American Society of Anesthesiologists (ASA) score, previous surgical abdominal procedures, white blood cells count, haemoglobin, and haematocrit were evaluated. The intraoperatively recorded data were: operative time (from creation of pneumoperitoneum to closure of final port), estimated blood loss (EBL), blood transfusions, intraoperative complications, and conversion rate. The postoperative data collected were: amount of abdominal drainage in the first 24 h, white blood cell count, haemoglobin, and haematocrit in the first 2 days, first passage of flatus, time to start oral sips, complications, hospital stay, and overall cost (the total bill at time of discharge).

Statistical analysis

The primary endpoint of the study was operative time. Secondary endpoints were intraoperative blood loss and morbidity. Continuous variables were compared using the Mann–Whitney *U*-test, with *P* values < 0.05 considered as statistically significant.

Results

Between February 2004 and February 2008, 186 patients underwent LN at our institution. The initial 50 cases were excluded to account for the learning curve. The remaining 136 patients (59 women, 77 men) were operated by either ES (*n* = 70) or USD (*n* = 66). The indications of LN were broadly classified into three groups: inflammatory (pyonephrosis, infected hydronephrosis, tuberculosis and xanthogranulomatous pyelonephritis), non-inflammatory (uninfected hydronephrosis, small contracted kidneys and LN done

for hypertension), and tumours (renal tumours and TCC of the renal pelvis). For preoperative parameters (age, sex ratio, BMI, ASA score, and previous surgical treatments) of the groups were similar (Table 1). Furthermore, there were no differences between the groups as far as indications of LN were concerned (Table 2).

Intraoperative results

The mean (range) operative time was shorter in the USD group, at 134.6 (90–210) min vs 141.8 (89–289) min, but this difference was not significant (*P* = 0.46). When we compared the different indications for LN, there were no statistically significant differences in operative time between ES and USD in non-inflammatory and tumour subgroups. However, the operative time in the inflammatory subgroup was significantly shorter with USD than with ES (Table 3), at a mean (range) of 141 (92–210) min for USD vs 197 (101–289) min for ES (*P* = 0.011). Intraoperative EBL was significantly lesser in the USD vs ES patients, at a mean (range) of 140.8 (35–290) vs 182.6 (50–330) mL (*P* = 0.032), irrespective of indication. There were no statistical differences in terms of intraoperative morbidity.

In the ES group, there were three complications (4.2%): direct inadvertent burn to bowel and diaphragm injury, both of which were repaired laparoscopically, and the third case had blunt injury to renal artery adventitial vessels during circumferential dissection by hook cautery, which was managed by application of Hem-o-lok clip proximally. In the USD group, there were also three intraoperative complications (4.3%): blunt injury to splenic vessels in one patient and lumbar vein complex in the second patient, both caused by excessive traction and were managed by selective use of metal clips. In the third case there was injury to the liver during dissection of the coronary ligament and

Table 1 Demographic data.

| Variable | ES | USD | <i>P</i> |
|--------------------------------------|-------|-------|----------|
| Number of patients | 70 | 66 | |
| Male/female ratio | 42/28 | 37/29 | 0.77 |
| Age, years, mean | 47.4 | 49.4 | 0.81 |
| BMI, kg/m ² , mean | 23.5 | 24.3 | 0.77 |
| ASA score, mean | 2.1 | 2.3 | 0.92 |
| Previous abdominal surgery, <i>n</i> | 14 | 16 | 0.76 |

Table 2 Indications for LN.

| Indications of LN | ES (<i>N</i> = 70) | USD (<i>N</i> = 66) | <i>P</i> |
|-------------------|---------------------|----------------------|----------|
| Inflammatory | 27 | 24 | 0.79 |
| Non-inflammatory | 33 | 31 | 0.81 |
| Tumour | 10 | 11 | 0.91 |

Table 3 Intraoperative data.

| Variable | ES (N = 70) | USD (N = 66) | P |
|-----------------------------------|-----------------|-----------------|-------|
| Operative time, min, mean (range) | | | |
| All indications | 141.8 (89–289) | 134.6 (90–210) | 0.46 |
| Inflammatory | 197 (101–289) | 141 (92–210) | 0.011 |
| Non-inflammatory | 106 (89–198) | 121.3 (90–200) | 0.21 |
| Tumour | 122.4 (104–262) | 141.5 (108–210) | 0.48 |
| EBL, mL, mean | 182.6 | 140.8 | 0.011 |
| Blood transfusion, n | 3 | 2 | 0.22 |
| Injury to other organs, n | | | |
| Bowel | 1 | 0 | |
| Splenic vessels | 0 | 1 | |
| Liver | 0 | 1 | |
| Renal artery | 1 | 0 | |
| Diaphragm | 1 | 0 | |
| Lumbar vessels | 0 | 1 | |
| Conversion to open, n | 9 | 8 | 0.26 |

was managed by application of Surgicel and argon-beam coagulation. The conversion rate to open surgery was 12.5% (17/136), with no statistical differences between the groups (ES nine vs USD eight). The reasons to convert to an open procedure were: bleeding (nine cases), presence of fibrosis or adhesions (six cases), and locally advanced neoplasm (two cases).

Postoperative results (Table 4)

There were no postoperative deaths and no difference in postoperative drain losses in the first 24 h between the groups. There were no significant differences between the groups when comparing blood counts, time to recover bowel function [time to first bowel movement; mean (range) ES 1.1 (1–4) vs USD 1.2 (2–5) days]; time to oral fluid intake [mean (range) ES 1.2 (1–5) vs USD 1.3 (1–5) days]; postoperative mean tramadol requirement [mean (ES 224 vs USD 223 mg); and postoperative hospital stay [mean (range) ES 4.4 (3–11) vs USD 4.1 (3–11) days]. Postoperative complication rates were

similar in the two groups, at 7.1% (five of 70) for the ES group and 6.06% (four of 66) for the USD group: two patients (one ES, one USD) had postoperative ileus, three had (one ES, two USD) port-site infection, one patient had a hernia (one ES), and four (two ES, two USD) required blood transfusion. One patient required re-exploration for an intestinal obstruction on day 5 in the ES group. The overall mean average cost of the operation was significantly more for USD than ES, at 59 000 vs 26 000 Indian Rupees (INRs) (Table 4).

Discussion

Electrocoagulation has become an indispensable tool for laparoscopic surgeons; however, there are safety issues for electrocautery that are unique to laparoscopy. The insulation of the instrument shaft must be intact to avoid injury. Injury may occur by direct contact, contact with another conductive instrument or capacitive coupling [15]. Electric current can produce high temperatures (100–200 °C) in the tissue due to tissue resistance,

Table 4 Postoperative data.

| Variable | ES (N = 70) | USD (N = 66) | P |
|------------------------------------|-------------|--------------|-------|
| WBC count, $\times 10^9$ /mL, mean | | | |
| Preoperative | 5.37 | 5.55 | 0.493 |
| Day 1 | 11.87 | 12.12 | 0.332 |
| Day 2 | 7.93 | 7.82 | 0.249 |
| Bowel recovery, days, mean | 1.1 | 1.2 | 0.215 |
| Start of oral intake, days, mean | 1.3 | 1.1 | 0.317 |
| Tramadol requirement, mg, mean | 224 | 219 | 0.241 |
| Hospital stay, days, mean | 4.4 | 4.1 | 0.379 |
| Postoperative complications, % | 6.9 | 6.7 | 0.423 |
| Ileus, n | 1 | 1 | |
| Port site infection, n | 1 | 2 | |
| Port site hernia, n | 1 | 0 | |
| Transfusion, n | 2 | 2 | |
| Average cost, INR, mean | 59 000 | 26 000 | 0.01 |

WBC, white blood cell.

resulting in degeneration, necrosis, drying, evaporation, carbonation, and eschar formation [16–18]. The introduction of the Ultracision, which converts electric energy into ultrasonic mechanical vibrations, allows cutting and coagulation with the same instrument [17], and its safety has been confirmed in various laparoscopic procedures [7–11]. USD works at a lower temperature ($< 80^{\circ}\text{C}$) thereby reducing the risk of thermal damage to adjacent structures as well as charring [18,19]. Furthermore, Ultracision is one of the few available multifunctional laparoscopic instruments that can be used as a grasper, dissector, coagulating device, and cutter (when used with a scissor-type tip). The mist (droplets aerosolised by the vibrations) generated by USD is generally less troublesome than the smoke from electrocautery [20], as it disperses more rapidly. However, the USD instrument is expensive and slower at cutting or coagulating. It can also injure nearby tissues either by a cavitation effect or by contact with the backside of the active blade, it needs disposable material, and significantly increases the cost of the laparoscopic operation [16,19–21]. Although the first LN was performed using ES there has been a gradual decline in its use in favour of newer energy sources, like USD, because of certain inherent drawbacks of ES [22]. However, it should be noted that most of the complications of ES were documented in the early period when the LN was evolving [23–24].

Our present study confirms the safety and efficacy of USD but fails to confirm any presumed clinical advantage compared to ES: all clinical and operative parameters were similar in the two groups except for a small difference (41.8 mL) in intraoperative EBL. Blood transfusion requirements and postoperative hospital stay were similar in the two groups. Whilst mean operative time in the overall groups did not differ significantly; on subgroup analysis patients with inflammatory conditions had significantly shorter operative times with USD. The intraoperative complications and conversion to open surgery were also similar in both groups, and were mainly seen in the inflammatory group. Thus, USD may be technically preferred for inflammatory conditions, e.g. pyonephrosis and xanthogranulomatous pyelonephritis, where LN is technically demanding because of adhesions and loss of tissue planes [25–26].

ES has been shown to be equally effective and safe as USD and more cost-effective than USD in randomised studies comparing use of ES with USD in laparoscopic colorectal surgeries and hysterectomies [12,27–28]. Monopolar ES instruments are available in different shapes, such as monopolar electrocautery knife, monopolar electrocautery hook, monopolar electrocautery scissors, and monopolar spatula, which can suit varied needs. We predominantly use a monopolar hook for dissection in LN. We realised three main advantages of ES monopolar instruments. First, the metal tip of ES

instrument only exposes a small area, which is rarely outside the laparoscopic vision during surgery, minimising the chances of injury. Second, the ES hook with its blunt back end can be used for blunt dissection without activating it and sharp dissection when activated, avoiding frequent exchange of surgical instruments. Finally, the hook can be used in fine dissection, especially around the vessels, and the back of the hook can oppress the bleeding point and achieve electrocoagulation when the tissue is bleeding with good haemostatic effect. We did not find a significant difference in the EBL, drainage volume, time to start of oral feeding, analgesic requirement, and leucocyte counts between the ES and USD groups, indicating that the local and systemic impact of the use of ES on the body was not significantly different compared with USD in LN.

Knowledge of the biophysics of ES and the mechanisms of ES injury is important in recognising its potential complications in laparoscopy [29]. ES can produce a higher surface temperature that is conducted over longer distance than that of USD [30]. Therefore, it is particularly important to understand how to use ES in LN in order to reduce the chances of thermal injury to the surrounding tissue. The correct method is to maintain a certain tension on both sides of the tissue separation space; let the ES slightly contact the tissue with its sharp edge, and then gently slide along the surface of the tissue in order to make a cut. The tissue is cut immediately into and slid aside to expose deep layer tissue and the important organs in the deeper layer tissue can be easily uncovered, thus reducing the possibility of the collateral thermal damage. Slower operative speed and a combination of piecemeal sharp and blunt dissection should be used at important anatomical positions. Current leakage and burn injury can occur due to insulation defects and we as a protocol use the reusable hook or forceps for 50 cases after which they are exchanged for a new one. Furthermore, all ES instruments are inspected for any insulation defect before use. To avoid coupling conduction injuries, we always use reusable metal trocars instead of hybrid trocars. One patient in the ES group had an inadvertent contact bowel injury, which was recognised and repaired intraoperatively. One patient operated upon for pyonephrosis required re-exploration because of an acute intestinal obstruction. On exploration the small bowel loops had adhered to renal fossa after the LN. There was no significant difference in postoperative complications, such as bowel injuries and wound infections, between the ES and USD groups in our present study, indicating that ES is as safe as USD in LN. The operative time was almost the same between the groups, although the cutting speed of ES was faster than that of USD. On the other hand, the intraperitoneal CO_2 must be exchanged regularly due to heavy smog generated by ES in order to maintain clarity of vision, although it might slow the operative speed of ES to a certain extent.

Compared with USD, ES has prominent advantages, including sturdiness, durability, low cost, and being suitable for LN in less developed settings.

In the current cost conscious medical environment, particularly in developing countries like India, the importance of fiscal responsibility rests heavily on physicians. Some authors have reported a reduction in cost per procedure, as the use of USD allowed a reduced number of alternative disposable items to be used [8,31]. Whilst others have shown that the use of USD significantly increases the cost of the operation [27,28]. We avoid using costly disposables and mostly rely on use of reusable instruments. Therefore, in our experience, Ultracision represents an additional cost to the laparoscopic procedure of ~33 000 INR. At our institute, like most centres in India, operative room and hospital stay costs do not impact overall cost as much as the cost of disposables and drugs [32]. Thus, a mean difference of 10 min in operative time does not compensate for the cost of the disposable instrument used in USD, as postoperative results (morbidity and hospital stay) in the two groups are identical. The cost-effectiveness apart from other clinical advantages for LN should serve as a strong impetus to expand its availability and utilisation as a viable option for patients in the third world.

The present study, being retrospective in nature has inherent limitations of selection bias. The energy source (USD or ES) was chosen based on the preoperative anticipated difficulty of the case. However, as stated earlier all cases were performed by a single surgeon (N.K.A.).

Conclusion

Most LNs can be completed using standard ES without any difference in outcome. USD facilitates completion of difficult LN particularly in inflammatory settings. Therefore, the use of USD in LN routinely or in selected indications is essentially a matter of cost. Use of ES for LN is as good as USD and is significantly cheaper.

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Nil.

Conflict of interest

Nil declared.

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