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Benefits of Intraoperative Fluorescence and Intelligent Insufflation in Hand-Assisted Laparoscopic Nephrectomy in Living Donor: Initial Experience

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ABSTRACT

Introduction: The innovative technique of hand-assisted laparoscopic nephrectomy, with smaller incisions and greater versatility for the surgeon, along with an intelligent insufflation system, minimizes intraoperative complications, ischemia time, and postoperative morbidity in the donor. The use of Indocyanine Green (ICG) has revolutionized the visualization of blood vessels and renal parenchyma, providing crucial information about perfusion for transplantation purposes.

Case Presentation: Surgery was performed on a 36-year-old male following the complete protocol for left kidney donation. The procedure lasted 06 hours and 15 minutes, with insufflation pressure set at 8 mmHg using an intelligent insufflation system. A total of 17.5 milligrams of ICG were administered in three doses. Indocyanine green filter was used for the dissection of Gerota's fascia, ureter, left adrenal vein, left gonadal vein, renal hilum, and ureteral section. Organ extraction achieved a warm ischemia time of only 03 minutes and 28 seconds. The patient was discharged due to clinical improvement after 48 hours. Follow-up on days 10 and 17 revealed no postoperative complications, pain-free status, and expected laboratory parameter evolution.

Conclusion: The integration of indocyanine green with the technique of hand-assisted laparoscopic nephrectomy using an intelligent insufflation system proves to be a promising approach, allowing clear identification of anatomical elements and facilitating surgery. This approach not only reduces transoperative risks but also decreases hospitalization time and postoperative morbidity, setting a new standard in renal surgical practice.

Keywords: Intraoperative Fluorescence • Indocyanine Green • Hand-Assisted • Minimally Invasive • Intelligent Insufflation System

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INTRODUCTION

Living-donor kidney transplantation offers benefits to the recipient such as better graft acceptance and reduced waiting time. However, it poses a risk to an otherwise healthy individual, leading to the development of various strategies aimed at minimizing postoperative morbidity in the donor [1].

The first laparoscopic Living-Donor Nephrectomy (LDN) was performed in 1995 by Ratner et al. This procedure reduces the risks associated with open surgery and offers a shorter recovery time. Hand-Assisted Laparoscopic Donor Nephrectomy (HALDN) facilitates more effective organ manipulation as well as proper traction through tactile sensation and blood vessel exposure. Moreover, it does not require an incision for kidney extraction, thereby reducing the warm ischemia time [1-2].

Indocyanine Green (ICG) is a type of intraoperative fluorescence comprising a tricarbocyanine compound soluble in water, relatively hydrophobic, with a molecular weight of 775 daltons [3-4]. After intravenous injection, it binds to plasma proteins, particularly to bilitranslocase; this is expressed in the renal parenchyma, less so in the glomeruli, and minimally leaks into the interstitium. It is eliminated through the liver unconjugated in bile. The dosage ranges between 0.1-0.5 mg/ml/kg. ICG can be visualized under Near-Infrared Fluorescence (NIRF) using a specialized camera [3].

ICG is employed in various scenarios in urology. It allows for clear identification of renal irrigation, enabling vessel clamping [5-6]. Consequently, it can be used in nephrectomies for transplant purposes or for allograft recipients, thereby reducing ischemia times [7]. In cases with complicated vascular anatomy or renal anomalies, fluorescence-guided visualization can detect small aberrant vessels that may have gone unnoticed in preoperative studies [8]. Also, a renal hypoperfusion defect detected with ICG allows for intraoperative corrective actions before irreversible damage occurs [9].

Similarly, ICG can be injected directly into the ureter to identify narrow areas. When analyzed during the intervention with fluorescence-either for a kidney intended for graft or for obstruction aids in selecting the ideal pyeloplasty technique. Should a segment of the ureter be poorly perfused, it can subsequently be excised to prevent future strictures [9]. Therefore, ICG fluorescence imaging is a useful method for evaluating ureteral blood flow and is expected to help reduce complications caused by ureteral ischemia [10].

The execution of laparoscopic surgery requires creating a pneumoperitoneum through intra-abdominal insufflation of carbon dioxide, commonly at pressures between 12 and 15 mmHg. This has an impact on the patient's cardiovascular and respiratory systems by decreasing venous return, and cardiac output, and increasing peripheral vascular resistance. It may also cause subcutaneous emphysema, pneumomediastinum, pneumothorax, or increased pain during the initial 48 hours post-surgery. Therefore, the minimum intra-abdominal pressure is required to reduce adverse effects in patients [11-12].

Conventional insufflation systems lead to oscillations in abdominal cavity pressure during suction or smoke evacuation, potentially causing cavity collapse that can only be compensated by increased insufflation pressure. Traditional trocars have a cannula with a one-way valve; gas escapes from the cavity when the trocar valve is opened to accommodate instruments. Moreover, the accumulation of smoke interferes with the surgeon's vision, which may necessitate more suction and instrument cleaning, thus extending surgery time [13].

A valveless insufflation system, introduced in 2011, is currently known as Air Seal [13]. This system employs valveless or membrane-less trocars and consists of a three-tube insufflator and a specialized trocar. It provides insufflation regulation, suction, and CO_2 filtration, constant smoke evacuation, and maintains a stable pneumoperitoneum. It also reduces postoperative pain in patients, maintaining pressures at 8 mmHg [11].

We will present the case of a 36-year-old male with a complete kidney transplant protocol to evaluate the impact of using intraoperative fluorescence and the intelligent insufflation system, Air Seal, in hand-assisted laparoscopic left nephrectomy.

CASE PRESENTATION

A 36-year-old male with a complete international protocol for kidney donation. Weight: 89.7 kg, Height: 1.85 m, BMI: 26.20. Mother with Chronic Kidney Disease (CKD) stage KDIGO V, secondary to bilateral polycystic kidney disease. Blood type: B+, non-smoker, occasional alcohol consumption 2 to 3 times per month. No alterations were found during the physical examination.

Study Protocol

An abdominal angiotomography was performed, reporting a volume of 168 cm^3 for the right kidney and 183 cm^3 for the left kidney. Two right renal arteries and one left renal artery are present. A single right renal vein and a single left renal vein are observed. No intraluminal abnormalities are found

Table 1: Urinary Function Tests.

Study	Results
Microalbuminuria/Creatinine (mg/dL)	1.8
Random Urinary Microalbuminuria	0.11
Random Urinary Creatinine	59.52
BUN (mg/dL)	13.6
Creatinine (mg/dL)	1.06
Glomerular Filtration Rate (ml/min)	89.84
BUN: Blood Urea Nitrogen	

in the renal blood vessels (Figure 2A).

Chest X-ray shows no abnormalities. The 12-lead electrocardiogram in sinus rhythm, with no signs of ischemia, injury, or necrosis. Echocardiogram within normal limits without changes in mobility at rest; LVEF 64%.

Assessed by Cardiology who indicated that elective surgery could be performed, no contraindications for surgical events, and low cardiovascular risk on the Detsky scale. Evaluated by Psychiatry, who determined there was no pressure for organ donation.

The complete protocol was presented to the transplant committee of Hospital Angeles Clínica Londres and was accepted as a related left kidney donor (Table 1).

The surgical marking was performed at three anatomical sites: in the left iliac fossa for AirSeal trocar placement, in the left paramedian line approximately 6 to 7 centimeters (cm) for Gelport placement, and finally, one in the left subcostal region for the camera (Figure 1).

Figure 1: *Surgical wounds at the marking site.*

Surgical Intervention

The patient is taken into the operating room, where two permeable intravenous lines are inserted into the left upper extremity using a 20-gauge catheter. General anesthesia is administered, followed by orotracheal intubation and the placement of a Foley catheter.

Indocyanine green is intravenously injected on three occasions (Table 2), and the patient is positioned for a lumbotomy (right lateral decubitus), with lumbar elevation and a flexed operating table. Support areas are protected, and compressive bandages are applied to the lower extremities.

An antiseptic technique is performed, and preparations

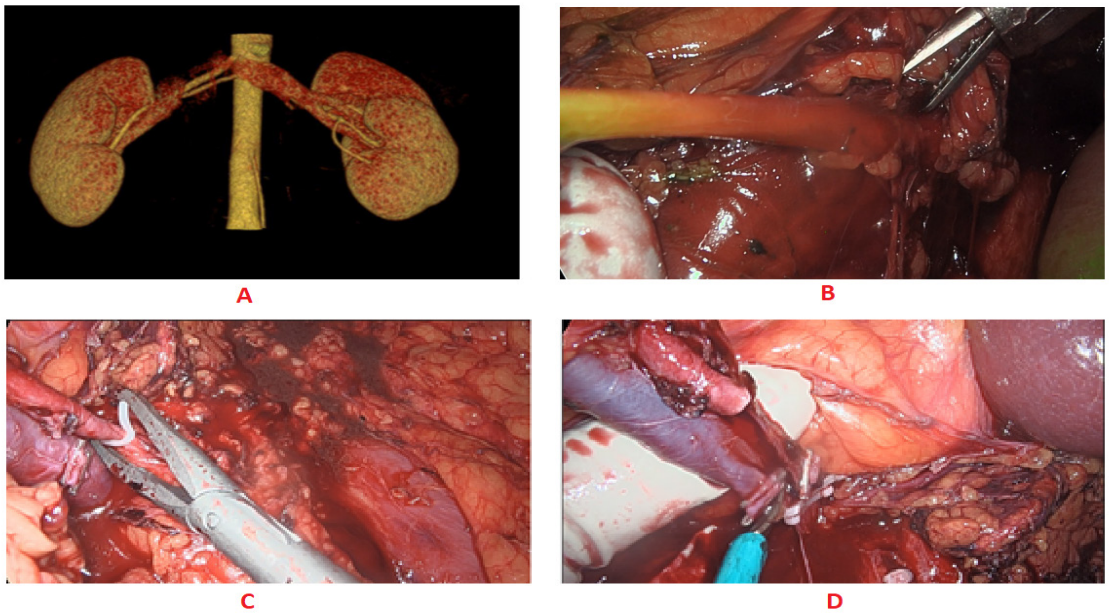

Figure 2: *A: AngioCT showing evidence of two renal arteries in the right kidney and one renal artery in the left kidney; B: Ureter section; C: Vascular clip is placed on the renal artery and cut; D: Vascular clip is placed on the renal vein and cut.*

are made for pneumoperitoneum and trocar placement. A 10-millimeter (mm) AirSeal trocar is inserted through an incision of approximately 6 cm to 7 cm in the supraumbilical region, a GelPort device is placed, and finally, a 5 mm port is set up for the camera. The abdominal cavity is insufflated to 8 mmHg using the intelligent AirSeal insufflation system.

With manual assistance, dissection of the descending colon is carried out with medial mobilization using an articulated Enseal device. The Toldt line is dissected to expose the retroperitoneum. The ICG filter is activated for incision into Gerota's fascia, exposing the perirenal adipose tissue and renal capsule. Clips are placed on the adrenal, lumbar, and gonadal veins and cut.

The renal artery and vein are exposed. The ICG filter continues for dissection of the left ureter (Figure 2B). The renal vein and artery are dissected (Figure 2C, Figure 2D). Two vascular clips are placed on the renal artery and cut. Two clips are placed on the renal vein and cut. Warm ischemia time begins. A 14 cm x 5 cm x 3 cm kidney is extracted through the GelPort and transported to a kidney table set up for bench surgery. Warm ischemia time ends at 03 min 28 sec.

An examination of the abdominal cavity and renal bed is performed, and hemostasis is verified. A complete count of the material is requested, trocars are removed, and the procedure proceeds to close the aponeurosis with a continuous suture and the skin is closed with subdermal sutures in the three ports.

DISCUSSION

Indocyanine green, when rapidly bound to plasma proteins following its intravenous administration, allows clear observation of renal perfusion. In donor surgery, ICG was administered on three occasions (Table 2).

After ICG was found in circulation, the filter was activated on six occasions (Table 3). No structural or anatomical alterations were found. During the dissection and cutting of the ureter, no sites of obstruction or stenosis were observed that would require the use of a more superior cut of the same.

Concerning the use of hand-assisted laparoscopic technique, the total duration of the donor's surgery was 06 hours 15 minutes, considering that their height is 1.85 m and they weigh 89.7 kg which extended the dissection time of Gerota's fascia and the renal hilum. A kidney measuring 14 cm x 5 cm x 3 cm was extracted directly through the GelPort, thereby reducing the warm ischemia time and also avoiding an additional incision for its removal or any injury or damage to the organ.

Regarding the use of AirSeal, insufflation pressures in the intra-abdominal cavity were reduced compared to those commonly used. No complications were experienced during the surgical procedure and the patient reported minimal postoperative pain.

Their post-surgical labs were within the expected values following the intervention (Table 4). Liquid diet was

Table 2: Administration doses of indocyanine green.

	Administered Dose	Route of Administration	Time of Administration	Surgical Moment
Indocyanine Green	2 ml (5 milligrams)	Intravenous	11:08	Anesthesia Induction
	3 ml (7.5 milligrams)	Intravenous	12:50	Ureter Dissection
	2 ml (5 milligrams)	Intravenous	13:47	Adrenal Vein Dissection
Total Dose	7 ml (17.5 milligrams)			

Table 3: Moments of usage of indocyanine green filter.

Moments of Usage of Indocyanine Green Filter			
Event Number	**Start of Use (Time)**	**End of Use (Time)**	**Surgical Moment**
1	12:29	12:·32	Gerota's Capsule Dissection
2	12:50	12:51	Ureter Dissection
3	13:22	13:23	Dissection of Left Gonadal Vein
4	13:47	13:48	Dissection of Left Adrenal Vein
5	14:12	14:13	Dissection of Left Renal Hilum
6	16:23	16:28	Section of the Ureter

Table 4: Renal function tests.

Control Laboratories	Day 0	Day 2	Day 9	Day 17	Reference Values
BUN (mg/dL)	19.6	21.6	30	29.8	6.0 - 20.0
Urea (mg/dL)	41.9	46.2	64.2	63	10.7 - 53.5
Creatinine (mg/dL)	1.07	1.81	1.86	1.88	0.50 - 0.90
Uric Acid (mg/dL)	7	3.4	6.2	6.9	3.4 - 7.0
TFG (CKD-EPI)	88.8	47	45.5	44.9	>60 ml/min
BUN: Blood Urea Nitrogen;CKD-EPI:Chronic Kidney Disease Epidemiology Collaboration					

initiated on the first postoperative day, progressing to a soft diet the same night. Assisted ambulation was instructed. The patient reported manageable, mild postoperative pain. They were discharged 48 hours after the procedure and attended a follow-up consultation on day 09 and day 17, showing favorable progress.

CONCLUSION

It is considered that the hand-assisted laparoscopic nephrectomy technique allows the combination of the advantages of laparoscopic surgery with open surgery by uniting minimal invasion with the surgeon's tactile ability, greater procedural versatility, and quicker resolution of surgical complications. Furthermore, it is possible to extract an organ suitable for renal transplantation, without additional injuries and with reduced ischemia time, improving the renal graft acceptance by the recipient.

The use of this technique, along with an intelligent insufflation system, minimizes complications in the generation of pneumoperitoneum as well as postoperative pain in the patient.

On the other hand, the use of ICG facilitates the identification of anatomical structures and their variants; moreover, it is a substance with low toxicity and ease of use, making it a highly useful component for transplant-related nephrectomies currently. However, the disadvantages that may exist are that after intravenous injection of the molecule, it can be lost in circulation, thus providing a limited opportunity for observation after its administration. Likewise, different allergic reactions in patients due to the use of ICG have been described, which, although extremely rare, should be studied in depth.

CONFLICT OF INTEREST

The authors declare no conflicts of interest.

CONSENT FOR PUBLICATION

The patient gave written informed consent to the publication of this case report and its accompanying images. On request, a copy of the written consent has been submitted to this Journal.

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