Anesthetic management of totally robotic right lobe living-donor hepatectomy: new tools ask for perioperative care

G. MARTUCCI, G. BURGIO, M. SPADA[1], A.F. ARCADIPANE

Department of Anesthesia and Critical Care IsMETT, University of Pittsburgh Medical Center, Palermo, Italy
[1]Department of Surgery IsMETT, University of Pittsburgh Medical Center, Palermo, Italy

Abstract. – Living donor transplantation is an accepted clinical practice in select transplant centers in Western countries to increase the availability of organs, while is standard practice in East Asian transplant programs. Living-donor right hepatic lobe resection is a particularly risky operation, with two mandatory outcomes: no serious complications for the donor, and an optimal graft-recipient body weight ratio.

The use of robotic surgery has increased worldwide thanks to its minimally invasive approach, and is now becoming suitable for living donor procurement. From the anesthetic point of view, robotic surgery reveals itself to be extremely challenging, and requires diverse capacities in teamwork and planning of anesthetic management.

We report what we believe is the first case of anesthetic management of a *totally* robotic right lobe resection in a living donor, and describe the steps taken by the anesthetists, in concert with the surgical team, to ensure delivery of the safest patient care.

Key Words:
Living-donor liver transplant, Robotics, Right lobe liver resection.

Introduction

Advances in transplantation medicine have led to a shortage of available organs. Living donation can reduce the chronic lack of organs from deceased donors. In adult to adult Living Donor Liver Transplant (LDLT) the right hepatic lobe is often the preferred graft to assure a better graft-recipient body weight ratio; but right lobe resection also carries the highest risk among all techniques of living-donor graft procurement[1,2].

In the last decade, minimally invasive procedures have become increasingly important in all surgical fields, with robotic technology representing one of the principal advances worldwide[3]. Minimally invasive surgery offers several advantages over conventional surgery: shorter hospital stay, less pain because of nerve-sparing, less blood loss and need for transfusion, minimal scarring, faster recovery, and a quicker return to normal activities[4]. All these advantages make minimally invasive surgery suitable for living donors.

While from the surgical point of view there is a number of advantages[5], computer-assisted robotic surgery presents several important challenges for the anesthetist, such as patient positioning; limited operating-room space and limitations to patient access; increased duration of the procedure (at least at the beginning of the learning curve); development of hypothermia; hemodynamic and respiratory effects of the pneumoperitoneum; and occult blood loss[6].

As teamwork is essential to the success of a robotic program, it is imperative for anesthetists to know these systems in order to recognize and prevent potential complications, and design an anesthetic plan for ensuring patient safety[7,8,9].

Our institute has been performing living-donor liver resection since January 2002, with 101 cases to date.

Here we describe the anesthetic management of the first case of a totally robotic procurement in a living donor at our Institute, performed with the da Vinci Robotic Surgical System® (Surgery Intuitive, Inc, Mountain View, CA, USA). Having rigorously searched PubMed and other databases for similar cases, this is the first case of robotic hepatectomy performed totally by minimally invasive approach, and there is lack of anesthetic reports on this field.

Case Report

A 46 year-old man (165 cm tall, 65 kg) volunteered to donate the right lobe of his liver to his

Corresponding Author: Gennaro Martucci, MD; e-mail: gmartucci@ismett.edu

brother, a 47-year-old man affected with hepatitis-C-related cirrhosis (Child Pugh B9 and MELD 10, but with repeated episodes of hydrothorax and moderate ascites). The donor, a bricklayer, was affected with hypertension (treated with losartan) and right arm and leg hyposthenia as a result of a childhood head trauma. A CT-Scan performed two months before surgery showed anathomic variants in hepatic artery, sovrahepatic veins and portal vein. The total hepatic volume was 1601 ml while the left lobe volume was 467 ml.

The day before the operation, which took place in March of this year, we tested the position of the operating table, the manipulator, the ventilator, infusions, the high flow fluid warmer (Level 1 Smiths Medical), the length of the extension tubings, and stopcock placement, as well as assessing the free spaces in which to move during the surgery. There were to be two anesthetists, one of whom is not slight of frame.

The day of operation, in our holding area, after attaching standard monitors, midazolam 1 mg was administered as sedation and, after local anesthesia with lidocaine 2%, we placed two 14 G cannulae (one in each arm) and a 20 G catheter in the left radial artery. An epidural catheter was placed in sitting position at T6-T7 with 8 cm in the epidural space.

Anesthesia was induced with midazolam 3 mg, fentanyl 200 mcg, propofol 120 mg, and cisatracurium 20 mg. The patient was intubated with a size 8.5 ETT (endotracheal tube), and a 7Fr 3 lumen central venus catheter was placed in the right internal jugular vein with ultrasound guidance. Monitoring included ECG (II and V5 derivation), invasive arterial pressure, central venous pressure, pulse oximetry, endTidal CO_2, bispectral index, temperature, urine output per hour, arterial blood gases after the creation of the pneumoperitoneum per hour, and baseline thromboelastogram. In accordance with our protocol for hepatic resections, we prepared the cell saver autologous blood recovery system, and connected it to the surgical aspirator.

After surgical positioning we placed several egg crate foam pads to cover the pressure points of the patient, who was placed in a semi-lithotomy, reverse Trendelenburg, supine position, with some rotation to the left. The table was at a distance from the ventilator, and was rotated 180 degrees away, with the robot positioned cephalad above the patient to permit the best performance of the manipulator. We laid an Olympic Vac-Pac on the table to immobilize the patient in the desired position, and to avoid the risk of sliding. The patient cannot be positioned and immobilized with shoulder straps and arm restraints, and cannot assume a "cross" position, with arms extended at 90°, as this would interfere with the movements of the robotic arms.

Maintenance was obtained with desfluorane at a dose of 4% with a flow of 1 L/min, and cisatracurium top-ups, while pain control was obtained with an epidural administration of morphine 2 mg at the beginning of the operation, and continuous infusion of bupivacaine 0.25% drip at 8 ml/h. For postoperative pain, a fentanyl patch of 25 mcg/h was placed in the morning, and paracetamol, three-times-per-day, together with an infusion of bupivacaine, was administered after surgery.

Ventilation was IPPV with Tv 540 RR 14, then 15. The FiO_2 was 40%. On first blood gas analysis, Hb was 14.1 and Hct 42, so we decided to start isovolemic hemodilution, keeping 450 ml of blood (replaced by 500 ml of tetraspan) at the beginning of the operation.

During resection we reached the following hemodynamic targets: MAP of about 70 mmHg, CVP of 1-3 mmHg, and urinary output of at least 1 ml/kg/h. Lactates were most of time under 1.5 with a peak after 10 hours of intervention of 2.4. Liquid infusions were balanced between the need for hydration and surgical need of lower CVP. Using the high flow fluid warmer we maintained a Temperature above 35.8°C. Pneumoperitoneum was created very slowly and the intraabdominal pressure was not more than 12 mmHg to minimize the hemodynamic changes.

All the operation was performed by minimally invasive technique and just for the estraction of the graft from the abdomen the surgeon performed a minimal laparotomy.

As expected, the intervention was quite long (12 hours), with no major surgical complications. The final graft weight before implant to the receiver was 1120 gr with really good correspondence with preoperative CT measurement. Respiratory, hemodynamic and urinary functions were monitored, with no significant change observed. At the end of the procedure we transfused blood obtained from hemodilution, and 420 ml of RBC obtained from cell saver. Thromboelastogram was normal at the beginning as well as at the end, so no additional blood products were administered.

The patient was extubated 13 hours after inducement of anesthesia, with good recovery, rapid return to consciousness, normal spontaneous breathing, movements of arms and legs as before the intervention, and absolutely no pain. Night observation in the ICU was planned, and the following day he was transferred to the surgical ward. He was discharged home 8 days after the operation, already in good physical condition, with decidedly improving lab results, and with a plan for repeated OPC visits over the following days.

Discussion

Robotic surgery is one of the latest surgical innovations with the largest potential impact, and its spread is limited not only by its high cost (both the equipment and the operating costs) but also by the burden it imposes on institutions in terms of planning, training, and clinical teamwork. Anesthetists must be aware of the important and rapid progress in this field, and of how it could affect their practice in terms of being able to best plan and ensure patient safety[3].

The da Vinci Robotic Surgical System provides 3D video imaging and a set of telemanipulated, flexible, effector instruments. The system consists of three principal components: a console for the surgeon, a patient-side cart with three or four interactive robot arms, and a vision cart that includes optical devices for the robotic camera. Robot arms hold the EndoWrist instruments, which provide seven degrees of motion – exceeding the capacity of a surgeon's hand in an open surgery, and two degrees of axial rotation to replicate human wrist-like movements.

There is little in the way of published anesthetic experience in robotic surgery, and no reports that we know on anesthetic management in robotic hepatectomies. There are no previous cases published of robotic hepatectomy totally performed by da Vinci System, because cases known always have been performed with a partial hand assisted technique to complete transection[2].

Computer-assisted robotic surgery presents several important challenges for the anesthetist, such as patient positioning; limited operating-room space, with limitations to patient access (Figure 1); increased duration of the procedure (at least at the beginning of the learning curve); development of hypothermia; hemodynamic and respiratory effects of the pneumoperitoneum; and occult blood loss[4,6,9].

Anticipating and planning movements and activities in the operating room are fundamental in management of robotic surgery because of the increased difficulty in facing unexpected emergencies when the robot is in position. Aware of this fact, we prepared well in advance. We plan on the basis of other robotic surgery reports, and of our own experience in living donor procurement.

Our care was directed to give the safest care to the patient (two cannulae and a cvc could be seen as redundant) and also to guarantee the most easy access to vascular lines in every case.

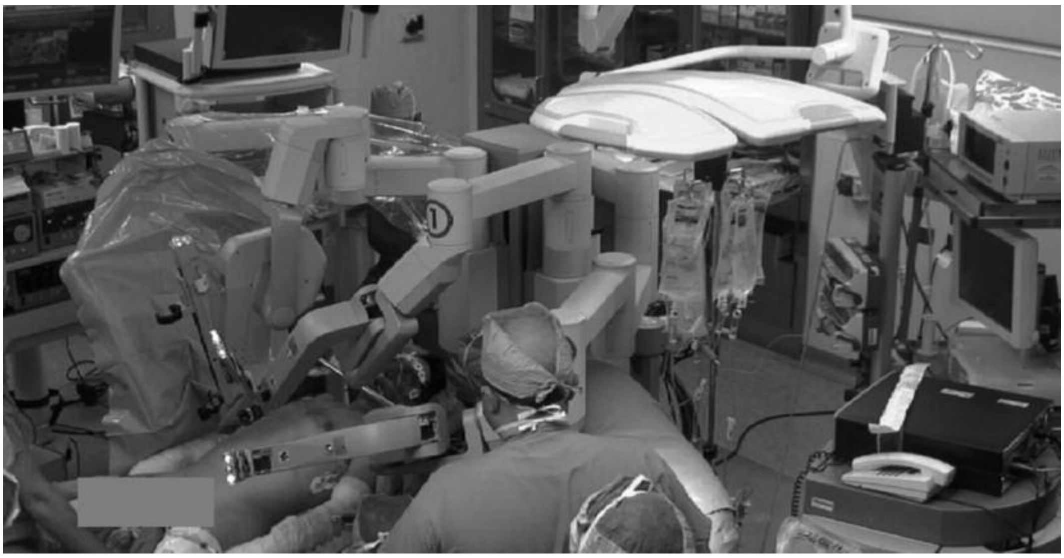

Figure 1. The patient position.

The duration was expected to really last long so we administered medication rapidly cleared like desfluorane and cisatracurium while opioids were used just for the induction because of combined anesthesia with epidural infusion of local anesthetic.

We faced hypothermia infusing only heated infusions, and balanced hemodynamics between surgeon's request and "patient" request. A TEG-based blood products administration let us to spare on plasma and platelets.

The technique permitted to procure a graft with dimensions highly comparable to the CT scan measures, with moderate blood losses for this type of intervention.

Conclusions

Our case highlights how a pioneering surgical technique can be used in a complex and delicate operation that, by definition in a living donor, must have a happy ending. In a well established surgical department, robotic surgery may well prove to be the most appropriate way to innovate practice in order to offer the best available care to patients. Innovations in surgical techniques and approaches can often require or prompt simultaneous innovations in anesthetic techniques and approaches, both of which are the basis for progress in the field[10].

In the lack of well established guidelines for anesthesia in robotics we present this uncomplicated case as an exemple of safe anesthesia care and as a possible way to follow for other centers.

Conflict of Interest

None.

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