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RESEARCH ARTICLE

TYPES OF ROBOTIC SURGERY: ADVANTAGES AND DISADVANTAGES OF CHOOSING THIS PROCEDURE

Isadora de O. Soler[1], Carla Cristine Orasmo[2], André Machado Garcia[3], Vivian Vilatoro Jodar[3], Délio T.M. Malaquias[1], Giovana Rocha Victorello[1], Juliana F.B. Paschoal[1], Breno Freitas Moyses Cristino[1], Thalita P.M. Alineri[1], Cristiana do Nascimento O. Beloto[1], Fernanda Lino Botteon[1], Ana Carolina C. Cruz[1], Ana Clara F. Parreira[1], Susanna K.O. Noleto[1], Mateus Elias F. França[1], Aline de Oliveira Mota[1], Roselene de O. Carvalho[1], Sadrak H. Cassoma[1], Alexandre D. Vivas[1], Jenyffer Victoria Cabrera[1], Mariana Machado Regonha[1], Júlio Elias Calheiros[1], Elisitt E. Valencia Cabrera[1], Isaac Oliveira Alves[1], Luiz Rodolfo Thomaz da Silva[1], Hannah Kamarowski Fontana[1], CaioVinicius de Sá Bertozzi[1], Leonardo Tomé da Silva[1], Rafaela del Grosso Reis[1], Carla Pupo Concone[1], Alana S. de Lima Bozzi[1], Brenda M. M. Rodrigues de Oliveira[1], Adriana F. Viana Delgado[1], Amanda Luiza B. Cordeiro[4], Hiromi M.K Fujishima[4], Thiago GabanTrigueiro[4], João Victor Almeida Dias[5], Hamilton Roberto M. de Oliveira Carriço[6], Giuliana Pagliace[7], Cristiano Bento Alvarenga[7], Thiago A. Rochetti Bezerra[8] and Ronaldo Machado Bueno[9]

1. Medical Student, University of RibeirãoPreto. Guarujá, São Paulo, Brazil.
2. Bachelor of Medicine, Faculty of Medical Sciences of Paraíba - FCM/PB, Brazil.
3. Medical Student, Nove de Julho University, Brazil.
4. Medical Student, Potiguar University, Natal, Rio Grande do Norte, Brazil.
5. Medical Student, Rio Verde University, Aparecida de Goiânia, Goiás, Brazil.
6. Medical Student, University of Southern Santa Catarina. Tubarão, Brazil.
7. Medical Student, UCP, Central University of Paraguay, Ciudad delEste, Paraguay.
8. PhD in Medical Sciences, University of São Paulo, RibeirãoPreto -Medical School, Brazil.
9. Bachelor of Medicine, Faculty of Medicine of the Federal University of Minas Gerais. Professor at the Faculty of Medicine of the Nove de Julho University.

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Abstract

Introduction: Robotic surgery has become increasingly accessible and is already a reality worldwide. Although several medical specialties have benefited from this technology, urology is the one that has most incorporated the use of robots into surgical procedures. When we talk about robotic surgery, many patients imagine that a robot is used to carry out the procedure autonomously. It must be made clear that it is the surgeon who controls the robot and that this equipment only reproduces the movements of the doctor's hands.

Methodology: This article is a systematic review, based on the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) methodology, which seeks to identify the most widely used types of robotic surgery today, their advantages and disadvantages.

Literature review: It is important for centers that apply robotics to follow standardized training, improve reporting and increase patient education in order to reduce errors related to robotic surgery. Robotic surgery should be performed by urological surgeons trained in robotics

Corresponding Author:- Isadora de O. Soler
Address**:-** Medical Student, University of Ribeirão Preto. Guarujá, São Paulo, Brazil.

and with extensive experience in robotic and laparoscopic surgery. It should also not be forgotten that adding robots to the surgical equation can create room for error in an area that is already complex and full of risks.

Final thoughts: Robotic surgery is getting better and better as more advanced robots are developed to overcome existing shortcomings. Patients should therefore expect better results from robot-assisted surgery as advanced machines are applied.

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Introduction:-

The word laparoscopy has Greek origins, "laparos", which means abdomen. Today, the term refers to a minimally invasive surgical procedure, often used in urological and other surgeries [1].

At the end of the device, a mini-camera transmits images to video monitors (videolaparoscopy). In this way, it is possible to perform simple or complex surgical procedures in a minimally invasive way on practically all the organs of the human body, which were previously only performed conventionally, through open surgery [1].

Laparoscopy is usually performed with the patient under general anesthesia. To perform the procedure, the doctor makes a small incision in the area that needs to be examined or treated and inserts a camera and other necessary instruments [2].

Laparoscopy has advantages for patients as it is a minimally invasive procedure, resulting in lower surgical risks, less bleeding and post-operative pain, faster recovery and reduced scarring [3].

Laparoscopic surgery is effective in treating diseases of the genitourinary system[1].Also called robotic-assisted laparoscopic surgery, robotic surgery is a minimally invasive procedure in which the surgeon manipulates a robot to make incisions, resections and reconstructions. Seen as an evolution of laparoscopy, it also has advantages over open surgery, being less invasive, with possibly less bleeding, faster recovery and shorter hospital stays [3].

After the popularization of laparoscopy in recent decades, modern robotic systems emerged in the mid-2000s to help perform minimally invasive surgeries, and this technique is increasingly used in urological surgeries. The robot allows for greater precision in movements and greater vision, making it easier to perform complex, minimally invasive procedures [4].

Currently, robotic surgery is one of the most widely used techniques for prostate (radical prostatectomy) and kidney (partial nephrectomy or radical nephrectomy) cancer surgeries, but also for reconstructive surgeries such as pyeloplasty for kidney obstruction [5].

In addition, when compared to traditional laparoscopic surgery, robotic surgery has several advantages, such as: greater precision in hard-to-reach places, better ergonomics for the surgeon, more intuitive movements and three-dimensional vision [6].

It's important to understand that today's surgical robots don't perform any movements on their own. Through a console, the surgeon is responsible for all the movements performed by the robotic system [7].

However, if any unexpected movements are made by the doctor, the robot triggers a safety command, temporarily locking the machine, as well as filtering the surgeon's movements, avoiding tremors and making them more delicate. What's more, if the surgeon removes his face from the control screen, the robotic device automatically locks, preventing possible harm to the patient [6].

Methodology:-

This article is a systematic review, based on the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) methodology, which seeks to identify the most widely used types of robotic surgery today, as well as their advantages and disadvantages.

A search strategy was developed based on the evaluation of an objective on the subject in question, which forms the basis of the study.

The search descriptors were selected from the Descriptors in Health Sciences (DeCS) website and then combined with the Boolean operator “AND”. The databases used for the search were: PubMed and the Virtual Health Library (VHL), where cross-sectional, cohort and case-control studies were evaluated, in Portuguese, English and Spanish.

In all, the result of the search in the databases using the descriptors, but withoutapplication of filters, resulted in 321 articles available. After applying the following filters, PubMed: Portuguese, English and Spanish language and type of literature being a cross-sectional study. VHL: Portuguese, English, Spanish and type of literature being an observational study, a total of 45 articles were selected.

After pre-selecting the articles, a research protocol was created which clearly illustrated the aim of the study, the data collection process and the criteria involved in including the articles. After the analysis 22 studies were excluded. Therefore, 23 articles were selected for this review.

The selection of material was based on the objective proposed by the study, with the inclusion criteria being articles that were related and relevant to the topic. Longitudinal, randomized, cross-sectional, case report and literature review studies were selected.

Text analysis

Robotic surgery has become increasingly accessible and is already a reality around the world. Although several medical specialties have benefited from this technology, urology is the one that has most incorporated the use of robots into surgical procedures [8].

When we talk about robotic surgery, many patients imagine that a robot is used to carry out the procedure autonomously. It must be made clear that it is the surgeon who controls the robot and that this equipment only reproduces the movements of the doctor's hands [8].

As well as robotic surgical forceps (FIGURE 1), the equipment also has a camera, which allows for a magnified, 3D, high-definition view of the organs to be operated on[8].

(A) (B)

Figure 1:- (A) Robotic surgical forceps. (B) Robotic surgery equipment at the SírioLibanês Hospital (São Paulo, Brazil).

Types of Robotic Surgery

Robotic Radical Prostatectomy

Robot-assisted laparoscopic radical prostatectomy or simply robotic radical prostatectomy (FIGURE 2) is the robotic surgical treatment of prostate cancer, in which the prostate and seminal vesicles are removed. In cases of more aggressive tumors, we also remove pelvic lymph nodes [8].

The use of robotic technology allows visualization and preservation of the nerves responsible for erection, which are very close to the prostate and, in addition to the benefits mentioned above, enables faster recovery of urinary continence [7].

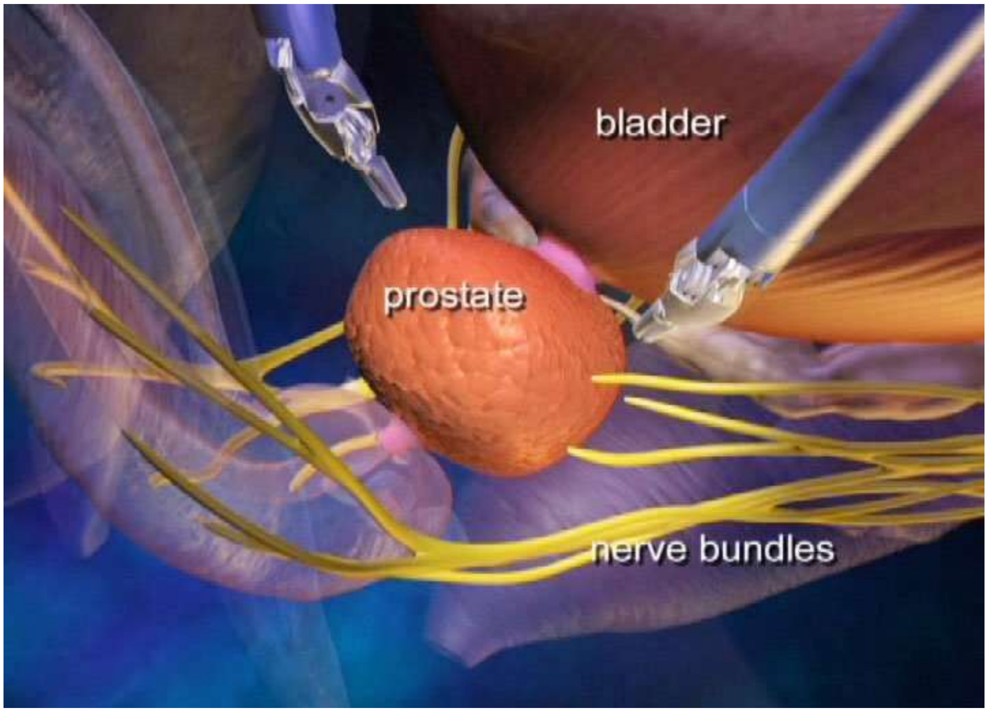


Figure 2:- Robotic radical prostatectomy. Source: (Cheapsbes et.al, 2024).

Robotic radical prostatectomy consists of removing the prostate gland to treat prostate cancer using robotic surgery. There are studies showing that the preservation of peri-prostatic innervation leads to better rates of preservation of sexual potency, however its effectiveness with regard to the preservation of urinary continence is still subject to doubt [6].

Simple Robotic Prostatectomy

While radical prostatectomy involves removing the entire organ, robotic simple prostatectomy removes only the "inner" part of the prostate, to treat benign prostatic hyperplasia (benign enlargement of the prostate), which compresses the urethra, making it difficult to empty the bladder [7].

The use of robotic technology considerably reduces the risk of bleeding and the length of hospital stay compared to open surgery [7].

Robotic Partial Nephrectomy and Robotic Radical Nephrectomy

Robotic partial nephrectomy (FIGURE 3) consists of removing the kidney tumor while preserving the rest of the kidney. The use of robotic technology is very useful for reducing the time it takes to clamp (obstruct) the renal artery, which is necessary during removal of the lesion and reconstruction of the site. This allows the function of the treated kidney to be maintained more adequately [9]. In cases where it is not possible to preserve the kidney, we perform complete removal of the organ using robotic radical nephrectomy [10].

Regardless of the nature of the disease, the use of robots reduces bleeding, hospitalization time and post-operative pain [10].

This is defined by your urologist, taking into account the size and location of the tumor in the kidney and whether removal of the tumor is possible, guaranteeing safe oncological treatment with maximum preservation of normal kidney tissue. These procedures are usually carried out by laparoscopy or with the aid of a robot. The advantages of using a robotic platform are more evident in cases of more complex tumors, where the 3-D visualization of the camera and the robot's articulated clamps help to remove the lesion and reconstruct the kidney [10].

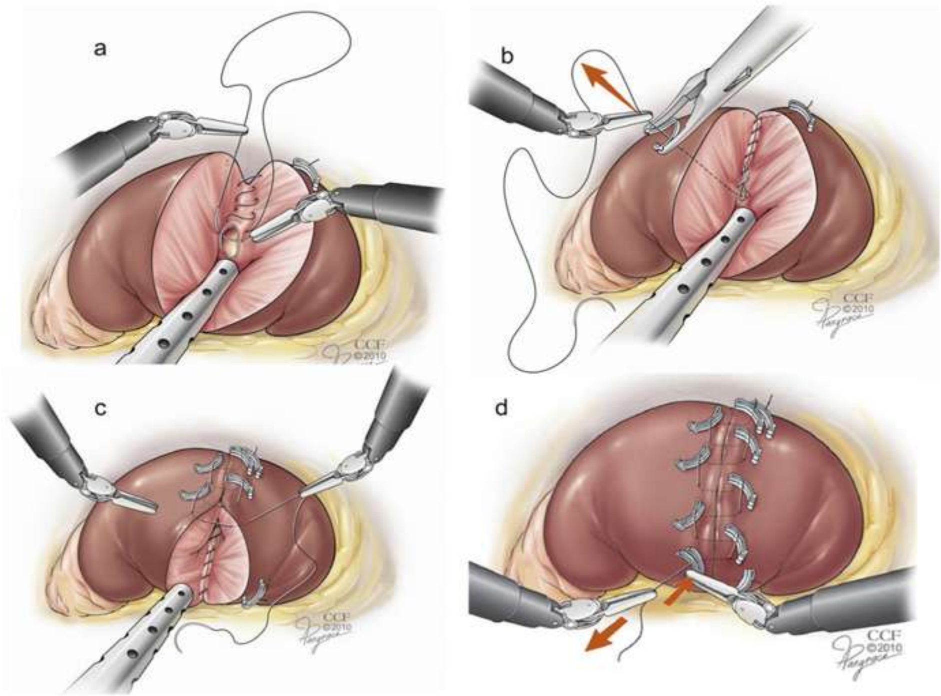


Figure 3:- Minimally invasive nephrectomy - kidney cancer. Source: urologistbhopal.

Robotic pelvic and retroperitoneal lymphadenectomy

Consists of removing lymph nodes that may be compromised by metastases from testicular, bladder, kidney or prostate cancer [11].

Retroperitoneal lymphadenectomy is a surgery to remove lymph nodes from the retroperitoneal region that aims to help in many cases of patients with testicular cancer[12].

The description of laparoscopic retroperitoneal extraperitoneal lymph node dissection for non-seminoma germ cell testicular cancer covers all aspects of the surgical procedure used to treat non-seminoma germ cell testicular cancer[13].

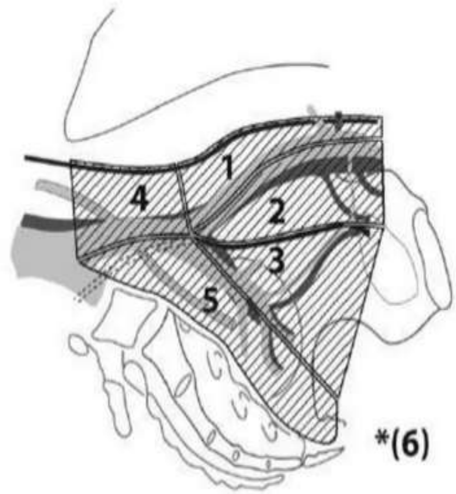
The set-up of the operating room, the position of the patient and equipment, and the instruments used are described in detail. The main technical stages of the surgical procedure are presented step by step: extraperitoneal approach, creation of space, left lymphadenectomy, right lymphadenectomy, end of procedure. Consequently, this operative technique is well standardized for the treatment of this disease[11].

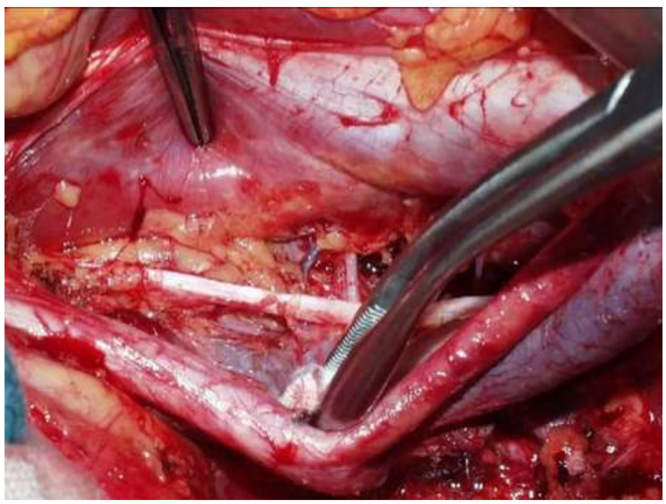
This procedure is indicated as a form of prevention or even as a complementary treatment after chemotherapy, when lesions persist on imaging tests[11].

The surgery tends to be quite long and even quite complicated, which is why, in some very specific cases, the use and assistance of the specialty of robotics may be indicated[11].

Retroperitoneal lymphadenectomy is surgery to remove the lymph nodes, which are nothing more than lymph nodes that are close to the cancer, where they may be the most likely to metastasize [11].

Lymph node chain	Boundaries of lymph node dissection Proximal - Distal - Medial - Lateral
External Iliac (1)	Bifurcation of common iliac artery - pelvic floor - midline of external iliac artery - genitofemoral nerve
Obturator (2)	Bifurcation of common iliac artery - pelvic floor - obturator nerve - midline of external iliac artery
Deep Obturator / Hypogastric (3)	Origin of obturator nerve - pelvic floor - bladder wall - pelvic side wall including triangle (fossa) of Marcille
Common iliac (4)	Aortic bifurcation - Origin of internal and external iliac artery - midline of common iliac artery - genitofemoral nerve
Presacral (5)	Triangle between midline of the common iliac arteries - bifurcation of internal and external arteries, dorsal border is sacrum and medial skeletonization of internal iliac vessels
Perivesical (6)	Lymph nodes along the outer surface (both sides) of the bladder specimen





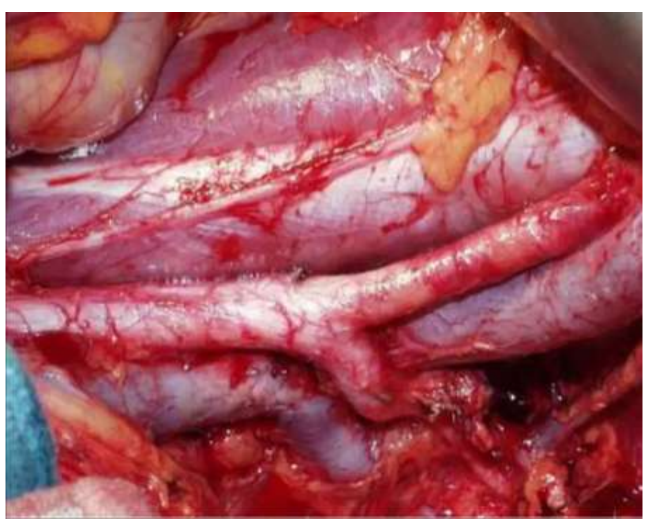


Figure 4:- Retroperitoneal lymphadenectomy.
Source: Garth H (2022).

Robotic Radical Cystectomy and Robotic Partial Cystectomy

Open radical cystectomy (ORC) is associated with high rates of perioperative morbidity and mortality, due to its extensive surgical nature and the high frequency of multiple co-morbidities in patients. As an alternative, robot-assisted radical cystectomy (RARC) (FIGURE 5) has been increasingly adopted around the world as a reliable treatment option using minimally invasive surgery [12].

Seventeen years have passed since the advent of RARC, and comprehensive data is now becoming available on long-term follow-up and analyzes various aspects, including oncological outcomes, peri-/post-operative complications, changes in post-operative quality of life (QoL) and cost-effectiveness [13].

In terms of oncology, RARC showed comparable oncological results to ORC. With regard to complications, RARC was associated with lower estimated blood loss, lower intraoperative transfusion rates, shorter hospitalization time, lower risk of complications and lower 90-day readmission rates than ORC [14].

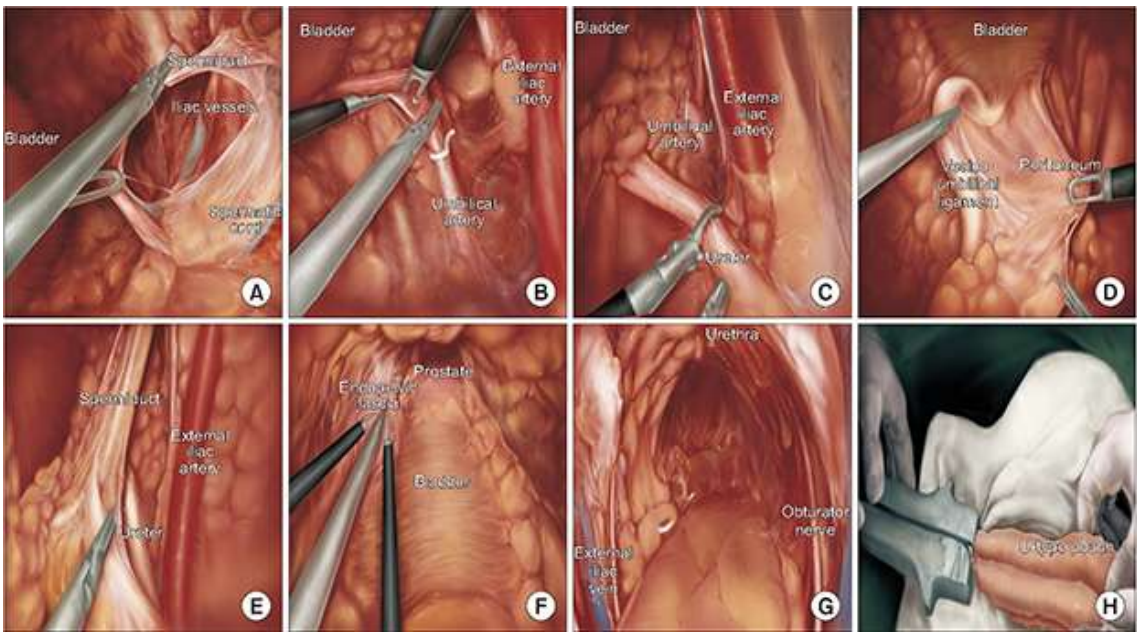


Figure 5:- Totally extraperitoneal laparoscopic radical cystectomy step by step. (A) Transection of the sperm duct. The sperm duct and the spermatic cord were transected separately. (B) Transection of the umbilical artery. (C) Identification and dissection of the ureter. The ureter was close to the peritoneum and the dissection range was from the common iliac artery to the ureterovesical junction. (D) Identification of the vesico-umbilical ligament. The vesico-umbilical ligament was transected and the peritoneum was separated from the bladder posteriorly. (E) Dissection along the spermiduct. (F) Dissection of the bilateral seminal vesicle followed by incision of the prostatic pedicles and remaining appendages. (G) Pelvic structure after extraperitoneal dissection of pelvic lymph nodes. (H) Extracorporeal confection of ilealneobladder. A lining clipper was placed in the ileum at the bottom of the pouch. Normally, two clips were enough for the neobladder.

In particular, RARC with intracorporeal urinary detour (ICUD) performed by high-volume centers significantly reduced the risk of serious postoperative complications. In terms of postoperative QoL, RARC with extracorporeal urinary detour (ECUD) showed comparable results to ORC, while RARC with ICUD was superior in some aspects. As the implementation rate of RARC increases and the learning curve is overcome, more prospective studies are needed [15].

Robotic pyeloplasty

The traditional gold standard for the treatment of ureteropelvic junction obstruction (UPJO) used to be open pyeloplasty, but in the minimally invasive era, new approaches have become apparent alternatives for the treatment of UPJO [16].

Furthermore, in recent years, laparoscopic pyeloplasty (FIGURE 6) has been rapidly advancing to replace open surgery as the gold standard in the treatment of UPJO [17].

Both the classic open approach and minimally invasive options usually have good results in favorable clinical situations (i.e. normal renal anatomy and no previous UPJO operations); however, the presence of anomalous anatomy or failure after a primary attempt to treat these patients is always worrying, so the approach to these cases requires a careful assessment of the best technique for performing the procedure [18].

Classically, the open approach has been one of the preferred options in the above scenarios, but in the current urological armamentarium, laparoscopic pyeloplasty has also been described as an option in the presence of complex anatomical cases or after a failed attempt to treat UPJO [19].

Although the laparoscopic approach seems to be a good and viable alternative for patients with UPJO, the learning curve for this procedure is steep, with some authors suggesting that a minimum of 50 surgical procedures of a high degree of complexity, performed over 1 year, with at least 1 procedure per week, is necessary to master the skills for this procedure [20].

In the presence of recurrent UPJO, this procedure can be even more challenging and technically demanding [21].

With the advent of robotic technology, the learning curve can be reduced. In addition, nowadays, robotic techniques have gained popularity, and several studies evaluating robotic pyeloplasty are currently available, indicating favorable results, even in the presence of challenging anatomical findings [22].

There are only a few studies showing the feasibility and results of the robotic technique in a challenging scenario, including patients with previously treated UPJO or patients with anatomical anomalies [22].

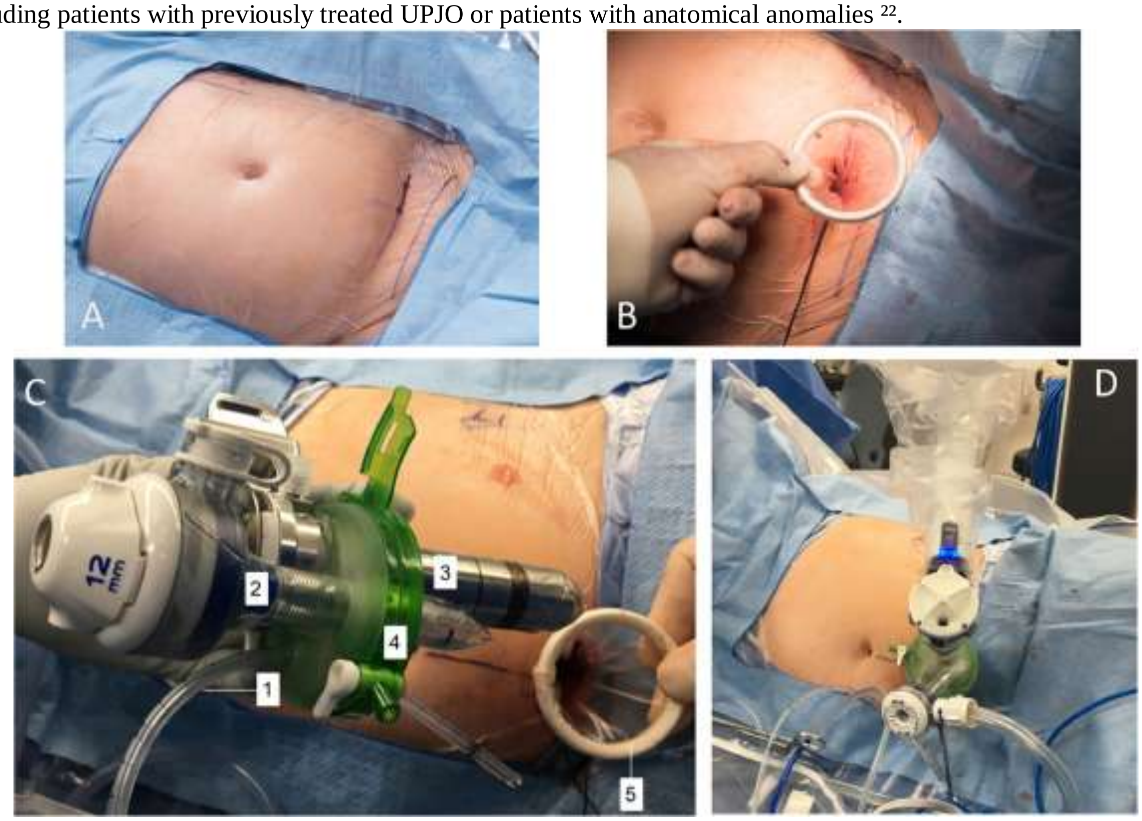


Figure 6:- Stage of laparoscopic pyeloplasty. Source: (Lefant et.al, 2020).

The surgical robot

The surgical robot is the main piece of equipment in robotic surgery (FIGURE 7). It is controlled by the surgeon via a console installed inside the operating room. The robot is made up of several articulated arms that are controlled remotely. Each arm has a specific tool, such as a camera, tweezers or scalpel, which is used during the surgical procedure [8].

The equipment is designed to reproduce the movements of the surgeon's hands with greater precision and stability. It has the ability to magnify the view of the surgical field, which allows the surgeon to see the area they are operating on in greater clarity and detail [8].

Figure 7:- Surgical robot. Source: uromedical.

The surgeon's console

The surgeon's console (FIGURE 8) is the control center of the surgical robot. It has a series of controls that allow the surgeon to adjust the position of the robot's arms, control the camera and select the tools to be used during the procedure. It has a pair of joysticks to manipulate the robot's arms and pedals to control the camera and other equipment [18].

Figure 8:- Surgeon Console Da Vinci XI with Chair.
Source: turbosquid.

The robot's vision system

The robot's vision system (FIGURE 9) is one of the most important features of robotic surgery. It allows the surgeon to see the area in which they are operating with greater clarity and precision. It consists of a high-definition 3D camera that is attached to one of the robot's arms [7].

The camera can be moved in various directions, allowing the surgeon to view different angles of the area in which they are operating. The image captured by the camera is displayed on two monitors on the surgeon's console (one for each eye) in real time. This allows the surgeon to make precise adjustments during the surgical procedure [9].

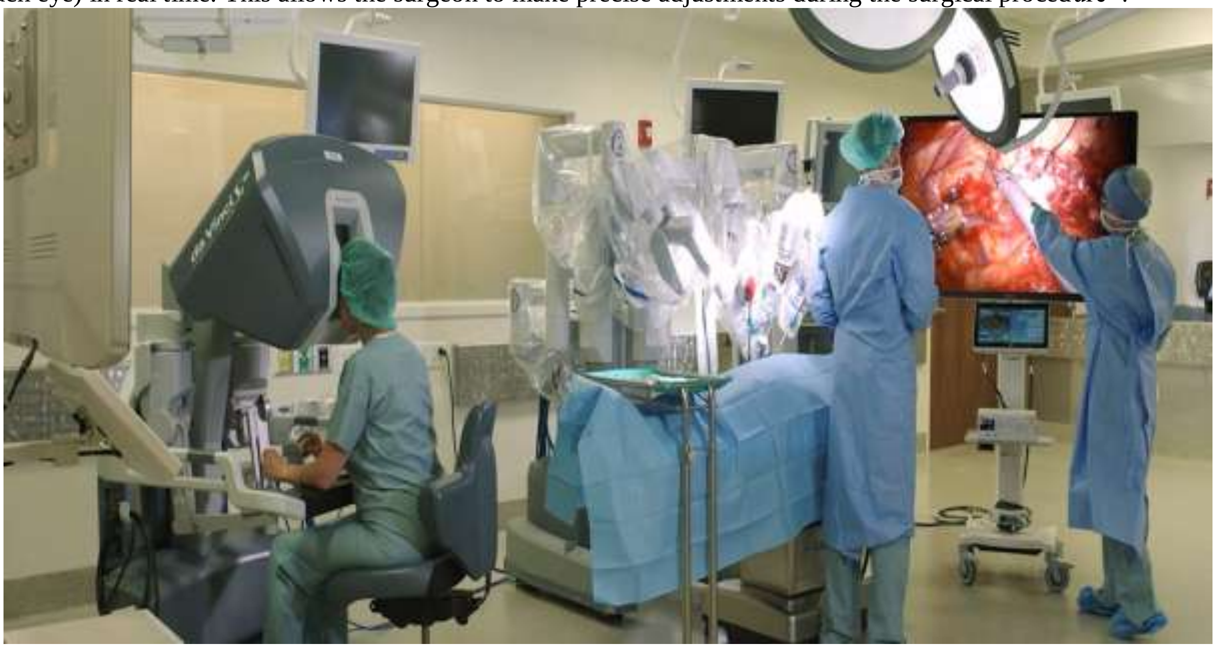


Figure 9:- 4K 3D surgical monitors and the medical video recorder.
Source: pro.sony.

Advantages of Robotics

For the patient, robotic surgeries, as they are minimally invasive, reduce blood loss, offer a lower risk of infection, which leads to a faster recovery and the patient's return to normal activities in a shorter space of time [21].

In recent years, surgical robots have helped transform the way doctors operate on patients. Robotic surgery helps surgeons to be precise during complex procedures, such as orthopedic surgery, but only requires incisions as small as a dime - even for large procedures [21].

During a robotic surgery procedure, three to four robotic arms are placed on the patient through small incisions. One arm has a camera and the other two arms replace the surgeon's hands. A fourth arm can be added to remove blockages from the path. The doctor can control the arms via a console, while a surgical team remains close to the patient during the procedure [21].

Although robot-assisted surgery is not something you may have thought of, there are several benefits for successful candidates. Here are four advantages of robot-assisted surgery;

Minimally Invasive

Since surgeons don't need to use their hands to access the body directly, smaller incisions are made compared to conventional surgery. Robotic arms can reduce the tremors of the surgeon's hands and reduce the likelihood of cuts or punctures that can lead to bleeding and infection [2].

Robot-assisted surgery can be great for candidates who need procedures in hard-to-reach places. In these areas, blood vessels, nerves and other important structures may be present, which can increase the risk of complications. The greater precision provided by the robot can reduce this risk [12].

Faster recovery time

Since robot-assisted surgery is minimally invasive, many patients will have a shorter recovery time compared to conventional surgery. It's important to remember that each person is different and that recovery time depends on the situation. However, the majority of people who underwent robotic surgery reported returning to daily activity more quickly than those who underwent traditional surgery [12].

In addition, since most robotic procedures can be performed on an outpatient basis, patients can save the time and cost of a hospital stay[12].

Less pain and blood loss

Since robotic surgery involves smaller incisions and greater precision, most patients feel less pain after the procedure. This can lead to less need for pain-relieving medication, which helps to reduce the risk of side effects such as stomach upsets or drug addiction. Blood loss from robotic surgery is also minimal [12].

Disadvantages of robot-assisted surgery

With robot-assisted surgery, there is not only the risk of human error when operating the robotic system, but also the potential for mechanical failure. For example, system components such as the robotic arms, camera, robotic tower, binocular lenses and instruments can fail [15]

In other cases, the electric current from the robotic instrument can escape from the robotic arm and be misapplied to the surrounding tissues, resulting in accidental burns [14].

Similarly, robot-assisted surgery can cause nerve paralysis due to the extreme positioning of the body or the direct compression of nerves that can occur when robots are used. Robotic surgery also takes longer to perform than non-robotic surgery in surgical centers with less robotic volume or by less experienced surgeons [14].

Final considerations

It is important that centers applying robotics follow standardized training, improve reporting and increase patient education to reduce errors related to robotic surgery.

Robotic surgery should be performed by urological surgeons trained in robotics and with extensive experience in robotic and laparoscopic surgery. It should also not be forgotten that adding robots to the surgical equation can create room for error in an area that is already complex and full of risks.

Therefore, appropriate measures must be taken to ensure safe and effective robot-assisted procedures. Robotic surgery is getting better and better as more advanced robots are developed to overcome existing shortcomings. Patients should therefore expect better results from robot-assisted surgery as advanced machines are applied.

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