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MULTI-INTSTRUMENT CARRIER: A NEW CONCEPT IN LAPAROSCOPY

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Summary.- *OBJECTIVES: Five or six perforations of the abdominal wall increase the possibilities of, organ injury, infection, or hernia. Laparoscopy originally offered great advantages and significant progress. Multiple abdominal ports are now considered superfluous, excessively traumatic and today hardly merit the term 'minimally-invasive-surgery'. All that led us to design a device to help surgeons meet new standards that can have several uses.*

METHODS: The instrument is a 4 cm diameter, 5 cm long cannula. The superior extremity or lid has five 5 mm sealed openings, one for the telescope and four for instruments. Below the lid and its notched retaining screw is the tap to insufflate the operating field. The peripheral flange limits insertion depth and seals the skin wound. Lids with more or less openings are available. The device has been proven first in a simulator and then five pigs of between 20 and 30 kg have been operated. In the first two cases the cannula was introduced through the umbilicus and a cystostomy with suture was made. In the other three cases a nephrectomy was carried out inserting the cannula through the flank.

RESULT: The experimental series has allowed us to get adapted to the cannula; we have verified that the diameter and the length of the device are optimal, and that the vision is excellent. Also the device is hermetic, since there is no loss of gas and the instruments are not trapped inside, what has allowed us to work and to suture without special difficulty.

DISCUSION: A single port through the abdomen or even transvaginally represent a real challenge to laparoscopy because in the 21st century to make 5 or 6 perforations in the abdominal wall appear untenable. Finally, with this system there are enormous possibilities for robotization with only one arm that includes the telescope and instruments, that sooner that we might imagine is going to revolutionize surgical practice.

Keywords: *Laparoscopy. NOTES. Natural orifice transluminal endoscopic surgery. Multi-instruments carrier. Nephrectomy. Robot.*

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Resumen.- *OBJETIVO: Cada vez resulta más obvio que 5 ó 6 punciones abdominales suponen un grave riesgo de lesión de una víscera, infección, hernia, dolor, además del efecto estético y que eso a estas alturas dista mucho de ser considerado un procedimiento mínimamente invasivo. Porque lo que en el siglo pasado, hace 20 años, eran grandes ventajas, hoy pueden ser serios inconvenientes. Por ello urge buscar alternativas menos cruentas y más acordes con los tiempos que co-*

rren. Todo eso nos ha llevado a diseñar un dispositivo, que creemos puede tener numerosas aplicaciones.

MÉTODOS: El instrumento consiste en esencia en una cánula de 4 centímetros de diámetro y 5 de profundidad. El extremo superior, a modo de tapadera, tiene 5 orificios de 5 milímetros, por donde van la óptica y otros 4 a su alrededor por donde van los diversos instrumentos. A un lado hay una llave de paso para el gas. Esta tapa es intercambiable, en caso necesario, por otra con dos orificios de 5 mm y otro de 12. El dispositivo se ha probado primero en un simulador y a continuación se han operado cinco cerdos de entre 20 y 30 kilos. En los dos primeros se introdujo la cánula por el hipogastrio y se realizó una cistostomía con sutura y en los otros tres se practicó una nefrectomía poniendo la cánula en el flanco.

RESULTADO: La serie experimental nos ha permitido adaptarnos a la cánula, hemos comprobado que el diámetro y la longitud de la misma son adecuados y que la visión es excelente. Asimismo el dispositivo es hermético, ya que no hay pérdida de gas y los instrumentos no quedan atrapados, lo que nos ha permitido trabajar y suturar sin dificultad.

DISCUSIÓN: Estamos convencidos de que un trocar único vía abdominal o incluso transvaginal supone un auténtico desafío a la laparoscopia convencional, ya que en el Siglo XXI realizar seis perforaciones en el vientre del paciente empieza a ser insostenible .Por último, con este sistema hay enormes posibilidades para la robotización con un único brazo que incluya óptica e instrumentos, que muy probablemente, antes de que lo imaginemos, va a revolucionar la práctica quirúrgica.

Palabras clave: *Laparoscopia. NOTES. Natural orifice transluminal endoscopic surgery. Cánula multiinstrumentos. Nefrectomía. Robot.*

INTRODUCCIÓN

Recently, we published an article in this journal titled "Digitally assisted radical prostatectomy" (1). Among other things we described a new endoscopic transperineal approach to the prostate through the virtual space between the prostate and the rectum in which we placed an inflatable balloon to separate the tissues. However, the space is insufficient to introduce operative instruments other than the telescope. Consequently, we abandoned this approach for subsequent work.

On the other hand, we recently operated to correct a post-hysterectomy vesico-vaginal fistula that although small was in the depth of the vagina just above the trigone. We resisted the temptation to carry out a laparotomy and because we thought it illogical and inadvisable to repair it by conventional laparoscopy we decided on an intrinsically difficult vaginal approach even though the operative field was deep and poorly visible and the evident senile degeneration would restrict the movement of the instruments. The operation was laborious but the result was satisfactory. This stimulated us to explore another option that is perhaps more logical, easy, and less invasive than conventional laparoscopy.

In 1985, Buess et al. designed a rectoscope that permitted instruments to be introduced to into the rectum to extirpate a tumour or even suture the rectal wall (2). However, the technique did not prosper, mory because oncological reasons than the technical difficulty.

Our consideration of an endoscopic approach, our awareness of the difficulty of the repair of this type of fistula and knowledge of the works of Buess led us to think how we might design an instrument that might have the potential to carry out many different surgical procedures, not only for urologists, but also for abdominal and thoracic surgeons. This instrument, described below, we patented in 2007 (OEPM P200703382).

MATERIAL & METHODS

The instrument is a single 4 cm diameter, 5 cm long cannula. The superior face or lid has five soft-sealed orifices that ensure hermetic closure (Figure 1). The central orifice receives a 5 mm telescope while the surrounding four 5 mm orifices serve to receive different instruments. On the body of the cannula below the notched lid-retaining screw is a sufflation tap. The peripheral flange below this stabilizes the cannula, seals the wound margin and limits insertion depth. A suture to fix the cannula firmly in place can be knotted around the spherical-headed studs on the body above the flange. The standard lid can be unscrewed to clean the operative field or extract an organ. If required the lid may be substituted easily by a lid with two 5 mm orifices and one of 12 mm. Into the soft seals of the orifices of this lid are inserted the valves that are mushroom shaped to permit wider angular movements of the instrument they receive (Figure 2).

A small (3 cm) incision is made in the skin before the instrument is introduced. The incision must be sufficiently short to ensure a gas-tight fit (Figure 3). The multi-instrument cannula is may be used for transvaginal approaches. We have not yet been found it

necessary to use a Hasson type blunt introducer. In future, different trocar lengths might be available to permit different to suit different types of procedures. The first prototype was 8 cm long; our present model is only five but we are developing a variable length telescopic version.

The prototypes and the technique are still in the experimental phase. We first tested the cannula in a surgical simulator designed by us. The fifteen cm deep simulator box has a 4 cm circular hole on the upper surface through which we introduce the instrument. We tested 5 and 10 mm telescopes with cero and 30º visual fields. When the end of the telescope was aligned exactly with the mouth of the cannula, we found that with the instruments positioned 10 cm beyond the cannula orifice, they enjoyed a 9 mm operational radius under complete visual control. This was sufficient to operate, suture and knot without much difficulty (Figure 4).

We operated on five pigs whose weights ranged from 20 to 30 kg. The first animal weighed 30 Kg. On this we practised bladder sutures. On the second animal we carried out bladder surgery that included a cystostomy and a Boari flap. In the remaining three animals we did nephrectomies. For two nephrectomies we introduced the cannula through the left flank and for the third, through the right (Figure 4). For the first approach to the bladder and for the first nephrectomy we placed an accessory trocar through which we could see the cannula and instruments from within the abdomen (Figure 3).

RESULTS

The simulator revealed that the visual fields were adequate. However, the fields of the different makes of the 5 mm telescopes differed considerably. That is to say that some of the 5 mm telescopes gave excellent images, that hardly differed from those of the 10 mm. Nevertheless, there were some 5mm optics that were disheartening to use.

Our experience leads us to opine that the ideal optic is one of 5 mm with a 30 º field of view. At present, the telescope can move within the cannula

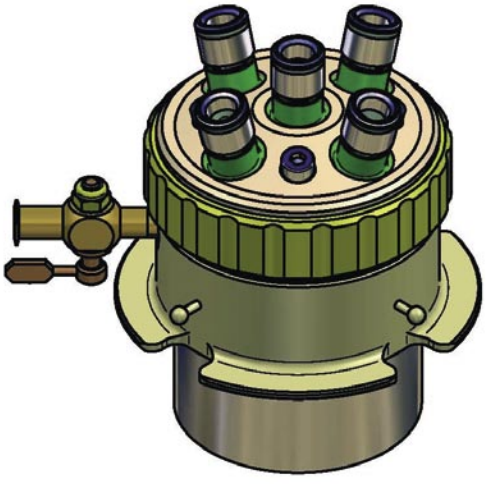

FIGURE 1. The cannula interchangeable lid has here five soft-sealed orifices.
On one side of the body is a gas tap. Below this is a peripheral flange that limits insertion depth and seals the wound.

FIGURE 2. Photo of the cannula with a version of the lid With only three orifices; one of 12 mm and two of 5, all fitted with soft valves.

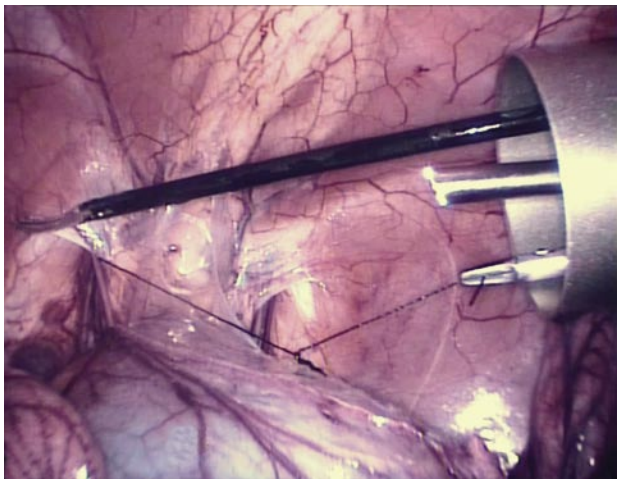

FIGURE 3. Image of the trocar mouth obtained with a second, auxiliary trocar positioned within the abdomen The optic and two instruments rest on the bladder.

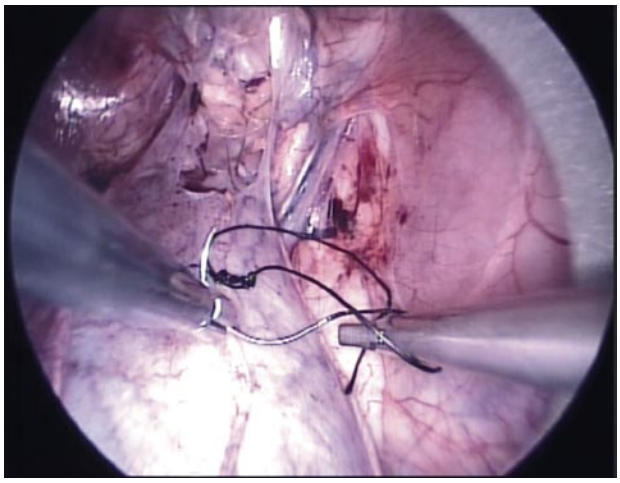

FIGURE 4. A knot is being tied with the cannula and instruments. Helped by the needle gripped by one of the forceps.

laterally and longitudinally, however we feel it will be better to attach it to the cylindrical wall free to move only longitudinally. The simulator proved particularly useful to help us adapt to the cannula and to explore its potential by making different types of sutures. The experimental work demonstrated that all new operators will need a period of practice. The instruments were always firmly supported, they did not interfere with one another and they showed no tendency to slip. The operative field is sufficiently wide to work, suture and knot without difficulty. We effectively demonstrated that our initial fears that the instruments might become trapped and that suturing might be difficult were completely unfounded.

The first animal was placed in the Trendelenburg position. The cannula was placed in the epigastrium and advanced to the bladder. The manoeuvre was more difficult than expected until we became fully adapted and able to suture with the level of skill developed in the simulator. We found that the ideal working distance was between 10 and 15 cm from the cannula mouth, but there was no particular difficulty to work at smaller distances and advance the telescope and instruments as required.

The subsequent operations corroborated our initial experience described above and we found that there was no advantage gained by introducing the cannula through the umbilicus and in fact for renal surgery we prefer to use a flank placement. At first we employed an accessory cannula to evaluate visually the technique we were soon able to dispense with it.

Of course, it is easier to suture if the instruments are separated, but after this small series we have developed new tricks to facilitate tying the suture when the instruments are as close as we now describe. With the forceps in the left hand we hold the needle with the suture inserted and that allow us to separate the tip of the forceps from the suture to easily make the loop and tie the knot (Figure 4). This small trick makes knotting as easy as if the instruments were some 10 or 15 cm apart. Furthermore, while opera-

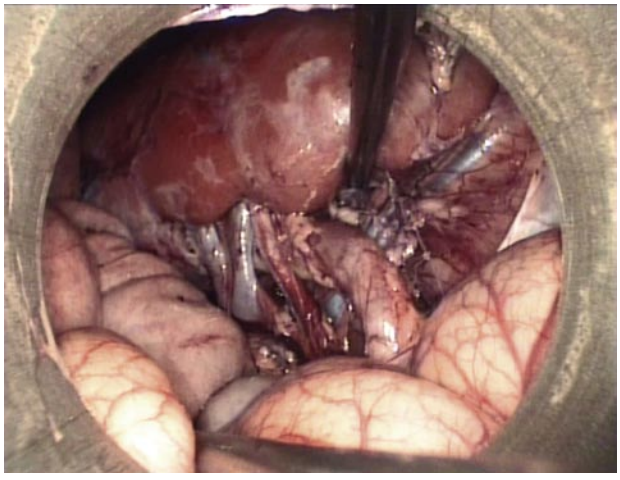

FIGURE 5. The upper instrument is lifting the inferior pole of the left kidney and revealing the dissected pedicle.

ting on the first pig we discovered that the smooth interior of the cannula reflected light and dazzled the operator so we decided to give the cannula interior a matt finish (Figure 5).

Similarly we saw that the cannula is well designed in that the initial 5 cm depth was appropriate and that the 4 cm diameter provided a sufficiently wide working field. When the cannula diameter was reduced it increased considerably the difficulty because the instruments tended to touch and cross.

The lids at present have a very fine thread that makes screwing them open and close slow and troublesome. We have now designed a bayonet type closure that makes a lid change as simple as press, twist and click.

The design and manufacture of the new soft valves was unusually difficult and cost much time to develop because they are not simple seals to prevent the escape of gas, they must flex elastically to allow the instrument to rock and rotate freely in them while they sit snug and firm within their recessed seats.

As we gained experience, the three-orifice lids proved to be more versatile than the multi-orifice ones, not only because the larger valves are more robust, but because three orifices were sufficient. Now the original five orifices appear to be excessive and we use the three orifice lids almost routinely.

DISCUSSION

Five or six 10 mm perforations of the abdominal wall are obviously more traumatic than one 30 mm incision (3). In addition, the use of just one trocar reduces the risks of hemorrhage and infection and of damage to a viscera. Post-operative pain is much less, there is less possibility of hernia or adhesions, recuperations are faster and the wound scar is less obvious and unsightly. We opine that the single trocar approach effectively challenges present-day laparoscopy and that in the light of its-numerous advantages for the surgeon and patient the technique will soon be widely adopted. We have felt for a long time that we were inflicting much damage to a patient when we had to make five or six wounds in the abdomen, Our great disquiet and our concern for our patients led us to develop the successful single trocar nephrectomy (4).

The use of the multi-instrument cannula that requires only one port considerably reduces hospital stays and the associated costs. The system is particularly appropriate for single-arm robotic surgery in which the telescope and the instruments are carried on just one-arm. This arrangement offers a versatile surgical tool that offers great savings of cost and time to the patient, the surgeon and the hospital. We predict that sooner than we might imagine the single-arm robots equipped with a multi-instrument carrier will have revolutionized surgical practice.

Recently a new practical surgical concept called NOTES (Natural orifice transluminal endoscopic surgery) has been employed to carry out nephrectomies via the vagina. These first works were hybrid procedures that used simultaneously abdominal trocars. Clayman describes several operations in which he used a one meter long, flexible instrument through which pass two 3 mm diameter instruments. That is to say, he used vaginal approach with a one meter, flexible instrument and two 3 mm diameter forceps with which he approached the renal vessels and the ureter to extract the kidney. Naturally several abdominal trocars were required to introduce the staplers, endoclips and other instruments. This technique successfully overcame a monumental surgical challenge because to triangulate the tissues, the essential manoeuvre for all types of surgery was considered impossible in this physically limited space.

Once again, Clayman has made an enormous contribution to laparoscopic surgery (5). In mechanics there is a concept called "moment of torsion" or torque that describes the moment of a pair of equal and opposite couples which tends to twist a body. In practice, this describes the function of a lever and is the mechanical principal of many surgical instruments. If we apply this principle to a flexible, one-meter long forceps we can see why transvaginal surgery to date has not been successful.

In spite of this, transvaginal nephrectomy with all its theoretical and practical defects represents a decisive step forward that has helped demonstrate that this type of approach is possible. We also tried to design a transvaginal approach but our multi-instrument carrier has still not been tried in this field. If we could use a rigid and stable platform similar to ours that would permit the use of stronger and more effective instruments, then transvaginal nephrectomies might be a practical proposition in the near future.

We fear that this present work might stimulate further doubts, some awkward questions and even rejection. In spite of this we are confident that the technique will give rise to a new generation of minimally invasive surgery that offers enormous potential benefits and may even become the harbinger of a second-generation laparoscopy.

REFERENCES AND RECOMENDED READINGS
(*of special interest, **of outstanding interest)

1. SÁNCHEZ DE BADAJOZ, E.; JIMÉNEZ GARRIDO, A.: "Prostatectomía laparoscópica digitalmente asistida". Arch. Esp. Urol., 58: 233, 2005.
**2. BUESS, G.; THEISS, R.; GUNTER, M. y cols.: "Endoscopic surgery in the rectum". Endoscopy, 17: 31, 1985.
*3. PARK, S.; BERGS, R.; EBERHART, R. y cols.: "Trocar-less instrumentation for Laparoscopy". Ann. Surg., 245: 379, 2007.
4. SÁNCHEZ DE BADAJOZ, E.; JIMÉNEZ GARRIDO, A.: "Nefrectomía con un solo trocar". Arch. Esp. Urol., 59: 719, 2006.
5. CLAYMAN, R.; BOX, G.; HABRAHAM, J. y cols.: "Transvaginal Single-Port NOTES Nephrectomy: Initial Laporatory Experience". J. Endourol., 21: 640, 2007.