Complications of Trocar Wounds and their Prophylaxis

OSVALDO CONTARINI, MD, FACS, FICS
MEMORIAL MEDICAL CENTER, BAPTIST MEDICAL CENTER
JACKSONVILLE, FL

Laparotomy is vision of the abdominal content by direct eyesight through an abdominal incision. Laparoscopy achieves the same or better result with an optic device placed into the abdomen through special introducers. Exploration, part or complete procedures, can be performed with much less postoperative morbidity; this has instilled a new sense of optimism in both the community and surgical ranks.

Suddenly it appeared that the old "sacred" rules of traditional surgery had been buried under a thick layer of dust.

Veress needles were inserted blindly into the abdominal cavity, with respect only to few basic rules, frequently taught by sales people with different professional ethics. The abdominal cavity: a Pandora's box even for open procedures!

Trocars of any size, shape and form, disposable and reusable, are used with the magic feeling that they cause no trauma and, upon their removal, the skin or at best the superficial layers of the abdominal wall can be simply closed.

Made for easy introduction through the tough layers of the abdominal wall they produce a wound, depending on their size, frequently even larger than a mini-laparotomy for appendectomy. The misnomer of "atraumatic" surgery remains a dream. Trocars became meat cleavers used for cream cheese!

Laparoscopic trocars do create wounds where the bowel or even the lifeless omentum can find their way.

Optimism with the new methodology ought to preserve unchanged the prudent principles that have educated most surgeons. Wounds, small or large, need to be treated with respect; the instruments that make them, need to be dealt with prudence

and appropriateness, rather than indiscriminately.

Less than a century ago in Dresda, G. Kelling performed in 1901 the first laparoscopy on a dog. Ten years later (1910) H.C.Jacobaeus, in Stockholm, performed it in humans, together with thoracoscopy and pericardioscopy. A long period of lethargy followed this innovative procedure, as technology was certainly nor ready for its successful development. However few important and basic events took place in this period. In 1920 Ordonoff created trocar cannulas with the same characteristics of the present reusable trocars. Kalk in Germany founded a laparoscopy school in 1929, developed angled scopes and used a second port to perform liver biopsies. CO_2 for pneumoperitoneum was first used in 1934 by Zollikofer in Switzerland; the use of the Veress needle was added after 1938, when Veress used it for therapeutic pneumothorax.

In the sixties a German gynecologist, K. Semm, resurrected this methodology, so cleverly that he should be considered the founder of modern laparoscopy. He was not only meritorious for the development of the modern insufflator and operative techniques (first laparoscopic appendectomy in 1972), but also of its divulgation throughout the world of gynecology.

Thanks to the improved video technology of the eighties, the prophetic intuitions of a French surgeon, Philippe Mouret (first laparoscopic cholecystectomy in 1987), and the readiness of the American medical industry, laparoscopy became a dominant driving factor within the practice of general surgery, with a success partially matched only by the mechanical staplers of the seventies.

Not an organized and scientific development ensued, but rather followed the order and the intelligence of a nuclear explosion. Enthusiasm, excitement prevailed over a scientific process. Fear to fall behind a rapid progress in surgery catapulted even the most inept surgeons into the field of laparoscopy. The idea that laparoscopic surgery was a new science, independent from traditional surgery, appeared to prevail.

In 1992 at a meeting of the Society of Laparoendoscopic Surgeons, during the presentation of a series of 100 consecutive patients who had undergone laparoscopic hernioplasty, I reported three cases of ventral hernias at the site of 12 mm trocar wound.[1] My report was at best accepted by many as a surgical oddity; the suggested prophylaxis as a useless surgical exercise.

During the following years, as the number of laparoscopic surgeons increased and concern for patients prevailed over fear of inadequacy and unfitness, surgeons began talking of similar mishaps and the medical literature began reporting more and more cases.

In reality the first report of ventral hernia at trocar site after laparoscopy had been made long before, in 1968 by R. Fears.[2]

Intra-abdominal complications, related to the use of trocars shall be dealt with in another chapter.

The previously mentioned tidal wave of general optimism made the report of such complications at best sporadic or frequently dispersed into much more complex reports of larger series of cases.

Complications of the trocar wounds are infrequent, often unsuspected, at times overtly dramatic, but usually of low incidence. They can be classified in:

- **Complications by insertion:** bleeding, nerve damage.
- **Complications by withdrawal:** bleeding, infection, bowel obstruction (incarcerated or strangulated ventral hernia, Richter's hernia), trocar site's hernia, ascitic fluid leak or anasarca in cirrhotic patients.

The onset of these complications can be immediate (bleeding), early (nerve damage, bowel obstruction, ascitic fluid leak, anasarca) or late (ventral hernia, causalgia, neuromas).

The site of insertion of a laparoscopic cannula is rarely complicated by **wound infection**, with a reported incidence ranging from 0.1 to 3% depending on the type of procedure: 0.1% for diagnostic laparoscopy, 0.25-1% for laparoscopic cholecystectomy, and 2-3% for laparoscopic appendectomy.[3]

Prophylactic criteria to prevent trocar's wound infections include proper toilette after removal of the gallbladder, or after having dealt with possible contaminants (bile, appendicitis, T-O abscess, bowel resections, ..), the use of metal extractors or protective plastic bags for the retrieval of contaminated organs.

Nerve injury can be frequently avoided by respecting certain areas of the abdomen where major nerve trunks are known to be present: inguinal area, medial and superior to the anterior iliac spine and close to the ribs. Transection of the nerves will manifest with an area of anesthesia distal to the transected nerve trunk. Causalgia usually originates early by trauma to the nerve trunk without complete transection. Late onset of pain follows usually complete transection or mild causalgia, with formation of a neuroma. This rare complication of operative laparoscopy is even less frequent when caused by trocars' insertion.

Bleeding at trocar' site is more common than expected, even if infrequently reported as a complication. Moderate bleeding can be present in any trocar wound and usually requires little or no treatment. More severe bleeding may be so intense as to dictate immediate control or discontinuation of the planned procedure. Of particular interest are the cases of bleeding caused by damage of the major abdominal wall vessels: inferior or superior epigastric vessels, patent umbilical vein, patent umbilical arteries, venous channels of collateral circulation after vena cava ligation, etc. Most cases of bleeding can be prevented by selective placement of the trocars. The rectus sheath is a particularly dangerous area, due to the epigastric artery and vein. Both vessels occupy a slightly lateral position within the posterior aspect of the rectus muscle; therefore any introduction of a trocar needs to respect these topographic areas. Patent embryonal remnants (umbilical arteries and vein, urachal vessels) need to be considered in younger patients and in case of cirrhosis. Portal hypertension and inferior vena cava ligation are most frequently associated with venous collateral circulation: lateral abdominal wall, inguinal areas and umbilicus. Transillumination with the laparoscope, after dimming of the room lights, in most patients (except real obese ones) will show most subcutaneous vessels, indicating

alternative placement sites.

Where bleeding may develop with any size of trocar used, **hernia formation** usually follows the use of larger trocars (10-12 mm) and more commonly in the lower abdomen. Hernia at the trocar' site has been described as an unusual complication, occurring in approximately 0.1-0.3%

Figure 1: Right sub-xiphoid trocar' site bleeding controlled with two vertical mattress sutures applied with Maciol Needles.

of cases.[3] Historically of unusual occurrence with small cone-shaped trocar tips, the wounds of sharp trocars, 10 mm or larger, are now a well recognized potential site for herniation.

A detailed review of some of the available literature dealing with this complication have been summarized in Table 1.
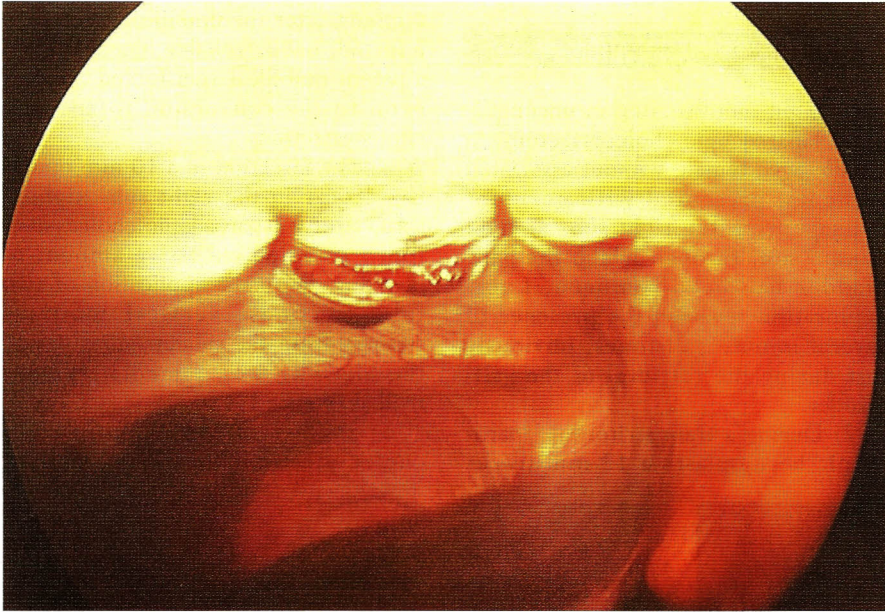
One more reason for the paucity of reports on this issue is due to the fact that hernias, without included bowel, can be asymptomatic and may manifest several years after the procedure.[15]

Since the beginning of my laparoscopic experience it has been an idiosyncratic habit to close every sizable trocar wound as completely as possible, without widening the skin incision.

My first report in a series of 100 consecutive laparoscopic hernioplasties showed an occurrence of 3%.[1]

Some of the reports of Table 1 did not clarify whether the fascia had been closed or not. In at least two cases of hernias (*) the fascia had been closed as completely as possible, however hernias did occur.

Figure 2: Anasarca of lower trunk, genitals and lower extremities, by intramural leakage of ascitic fluid from 5 mm trocar wounds, after laparoscopic cholecystectomy.

Literature Reports of Hernias at Trocar Site

Author	Case	Ref.	Procedure	Trocar-X	Symptoms	Onset	Site	Type
Fear (1968)	1	[2]	Lap	10	NA	NA	Umb	NA
Schiff (1974)	1	[4]	Lap	10	N/V	2 D	Umb	SB I
	1		Lap	10	N/V	14 D	Umb	SB
Bourke (1977)	1	[5]	LB	12	N/V	6 D	Umb	RSB
Rajapaksa '83	1	[6]	TL	10	0	5 D	Umb	Om I
Sauer (1984)	1	[7]	Lap	10	P/N/V	6 W	Umb	SB I
Hogdall (1987)	1	[8]	TL	12	P/N/V	8 H	Umb	RSB
Kiilholma '88	1	[9]	TL	10	P	5 D	Umb	RSB
Thomas (1990)	1	[10]	TL	10	N/V	1 D	Umb	SB I
Maio (1991)	1	[11]	VLC	10	P/N/V	3 D	Umb	SB I
Mealy (1991)	1	[12]	VLC	10	NA	??	?	SB
Contarini '92	1	[1]	LIH	12	P/N/V	4 D	LLQ	SB S
	1		LIH*	12	P/N	4 M	LLQ	Om I
	1		LIH*	12	P	5 M	LLQ	Om
Kurtz (1993)	1	[13]	Lap	10	P	NA	Umb	NA I
Plaus (1993)	1	[2]	VLC	10	P	3M	SX	Om I
	1		VLC/Lap	10/12	P	1 W	Umb/SU	Om I
	1		VLC	10	P	1 Y	SX	Om I
	1		VLC	10	None	1 M	SX	Om I
	1		Lap	10	P	4 M	SP	Om I
Radcliff '93	1	[14]	LIH/Orch.	10	P/N/V	7 D	RLQ	RSB
Williams '93	1	[15]	VLC	10	P/N/V	9D	Umb	RSB/I
	1		TL	10	P/N/V	8 Y	Umb	SB S

Table 1 Legend: TL= Tubal Ligation; Lap= Laparoscopy; VLC= video-laparoscopic-cholecystectomy; LIH= laparoscopic inguinal hernioplasty; Orch= orchiectomy; P= pain; N= nausea; V= vomiting; D= day; H= hours; M= month; W= week; Y= year; Umb= umbilical; RLQ= Rt lower quadrant; LLQ= Lt lower quadrant; SX= sub-xiphoid; SU= supra-umbilical; SP= supra-pubic; RSB= Richter's hernia small bowel; SB= small bowel; Om= omentum; I= incarcerated; S= strangulated; * = Fascia sutured.

Table 1.

Figure 3: Upper G.I. X-ray of the abdomen showing complete small bowel obstruction, from strangulated hernia at trocar site.

It appears evident that even if hernias cannot be completely avoided by closure of the superficial fascial layers, at least a lesser degree of severity has shown: omentum vs. bowel.

For early diagnosis of Richter's hernia and early post-laparoscopic small bowel obstruction, it has been suggested that they may be heralded by early postoperative ileus.[15]

CASES PRESENTATION

1) Eight months after an uncomplicated laparoscopic cholecystectomy, a middle aged female without associated ailments, presented with purulent drainage from the right sub- xiphoid trocar' site, through which the gallbladder had been removed. Local exploration revealed the presence of several minute gallstones, obviously lost during the retrieval of the gallbladder.

2) During a transperitoneal laparoscopic hernioplasty a 12 mm trocar was introduced erroneously through the lateral aspect of the rectus sheath with injury to the inferior epigastric vessels. After several attempts to preserve the laparoscopic approach, by widening the skin incision and exploring the rectus sheath, the persistent bleeding forced the surgeon to convert to an open procedure.

3) During a laparoscopic cholecystectomy, after the umbilical trocar was inserted, uncontrollable bleeding from a patent umbilical vein forced the surgeon to the conversion to an open cholecystectomy.

4) The insertion of a 10 mm operative trocar in the right sub- xiphoid area, after a laparoscopic cholecystectomy, revealed excessive amount of bleeding. With the application of two full- thickness vertical mattress sutures, from the subcutaneous tissue, the bleeding was immediately controlled (Figure 1).

5) a: After successful laparoscopic cholecystectomy in a young patient
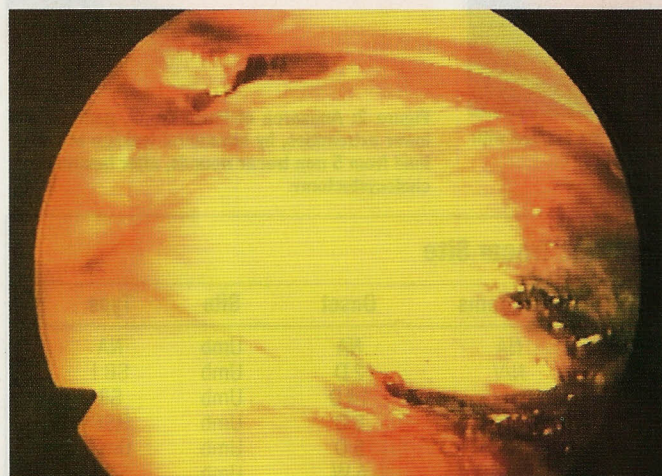

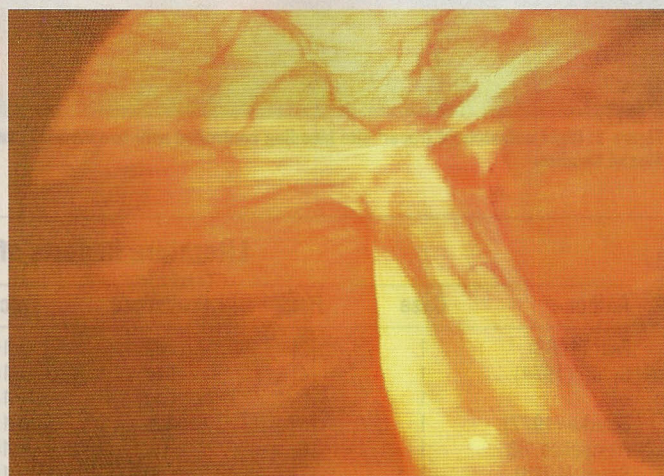**Figure 4a. 12 mm trocar wound closed externally (incomplete closure).**

Figure 4b. Incarcerated omentum at 12 mm trocar site (same as 4a).

Figure 4c. The strangulated, intramural portion of incarcerated omentum. Shown by external pressure.
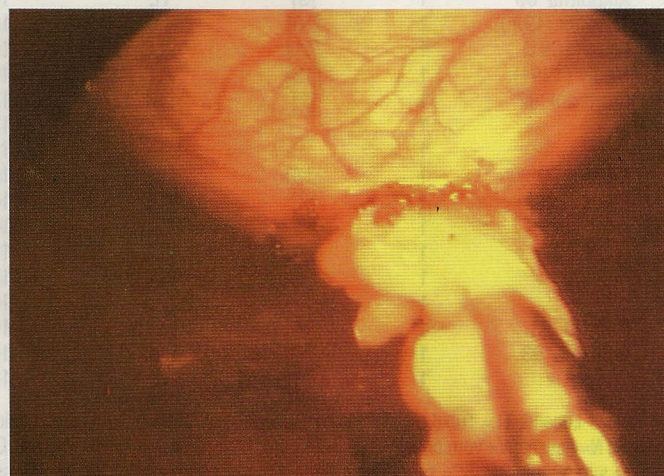

Figure 4d. The strangulated, intramural portion of incarcerated omentum. Shown by internal traction.

with liver cirrhosis and ascites I elected to close the larger trocar wounds completely, leaving the peritoneal opening intact at the level of two 5 mm trocar wounds. Within two days the patient had developed severe anasarca of the abdomen and lower extremities, together with early hepato-renal syndrome (Figure 2). Only intensive medical treatment led to full recovery.

b: A case similar to 4-a was treated without complete closure of the two lateral (5 mm) trocar wounds, external ascitic fluid leak complicated significantly the postoperative course.

c: An analogous case was treated with complete closure of three trocar wounds; at one of the 5 mm wounds a closed-system drain was applied for "controlled evacuation" of ascitic fluid until full recovery. The postoperative course was uncomplicated.

6) a: A young obese patient, after endoscopic hernioplasty had a protracted postoperative ileus. On the fourth postoperative day complete small bowel obstruction was diagnosed (Figure 3). Laparotomy revealed stran-
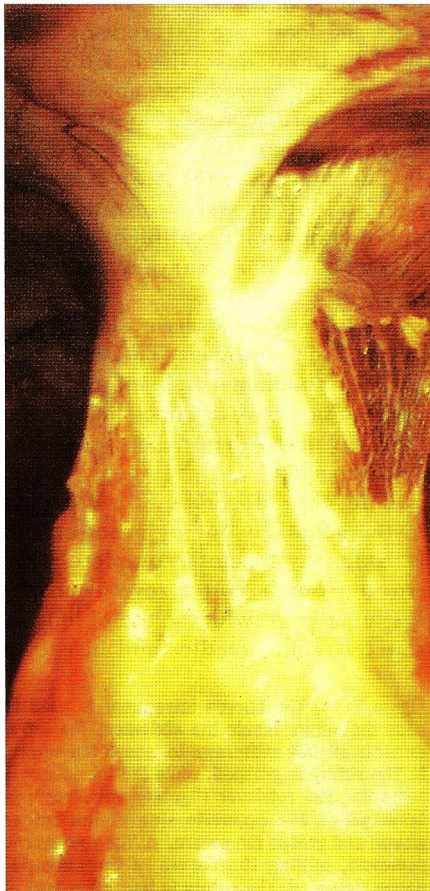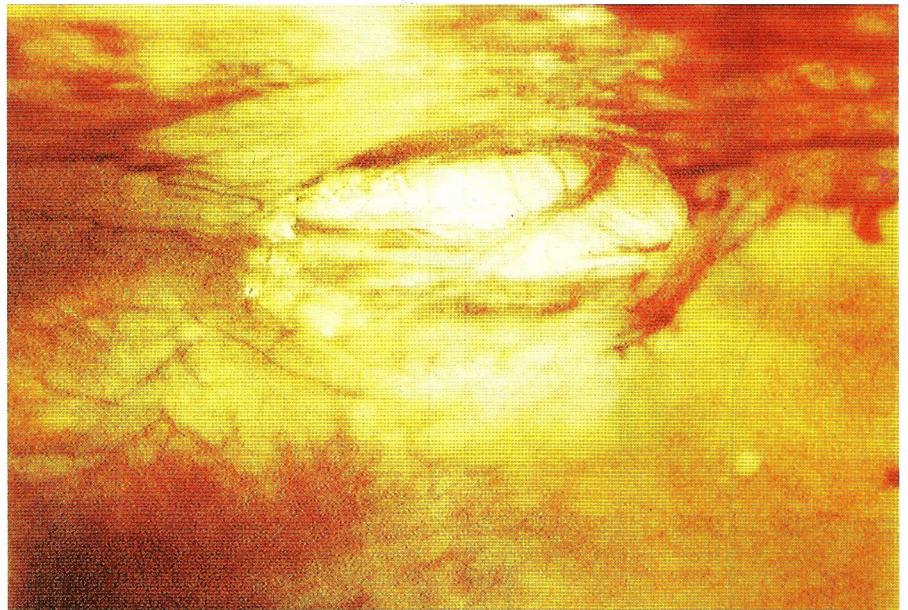

Figure 5b. Trocar' site ventral hernia, after removal of incarcerated omentum.
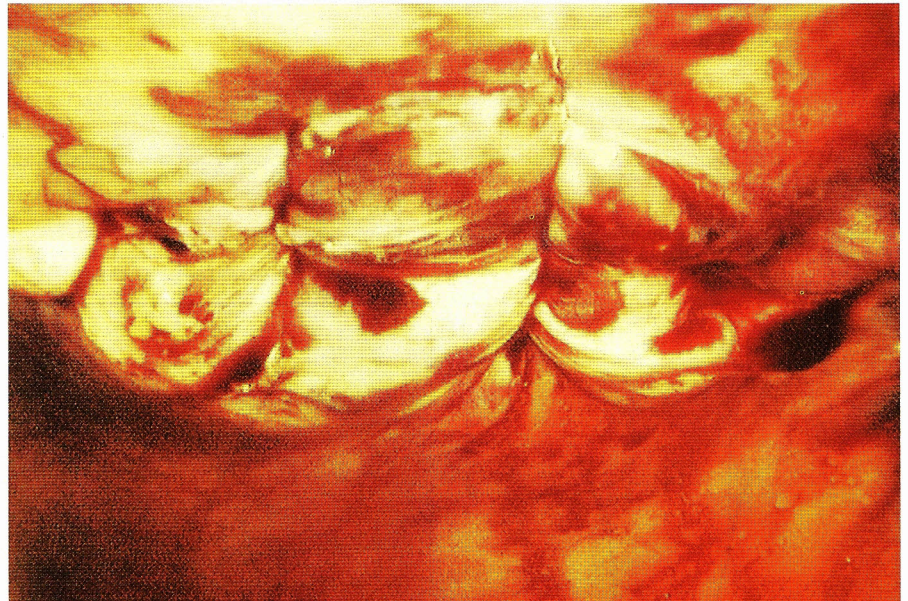
Figure 5c. Endoscopic repair of trocar' site ventral hernia with Maciol Needles.

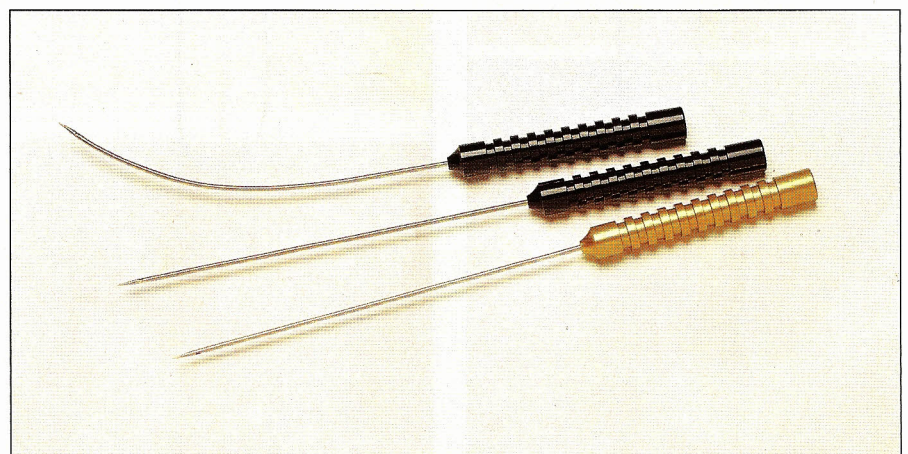Figure 5: a) Incarcerated omentum at 12 mm trocar site.

Figure 6: The Maciol Needles Set: straight and curved introducers (black handles) and a straight retriever (golden handle). (Courtesy of Core Dynamics,Inc.).
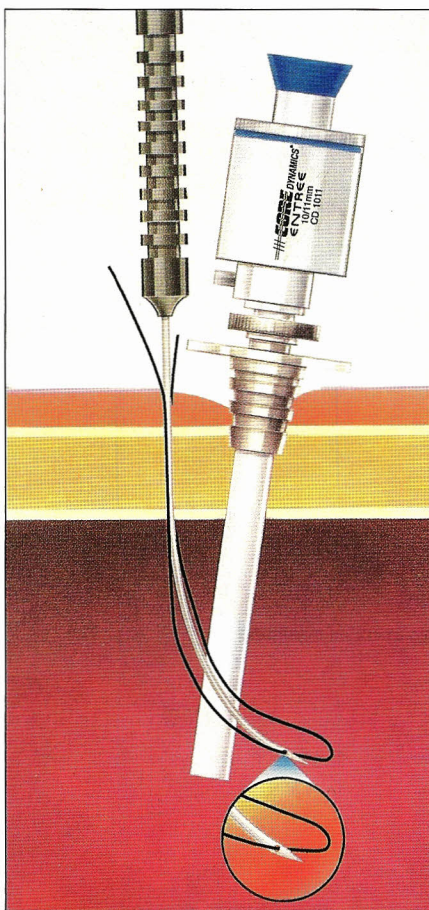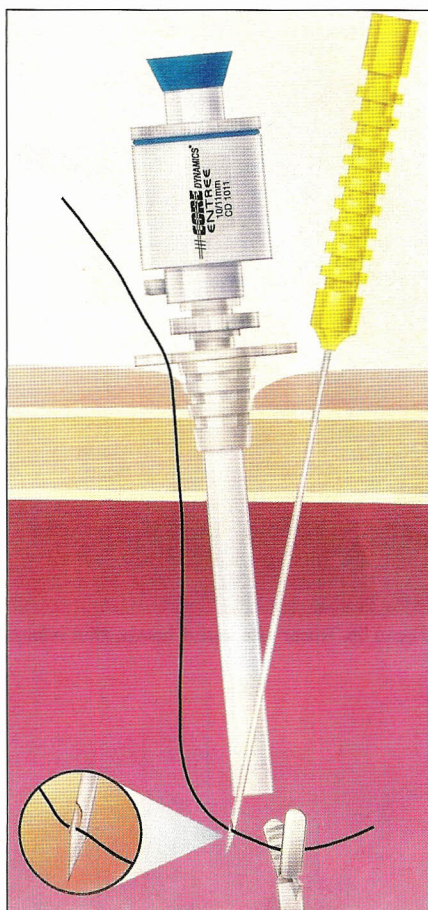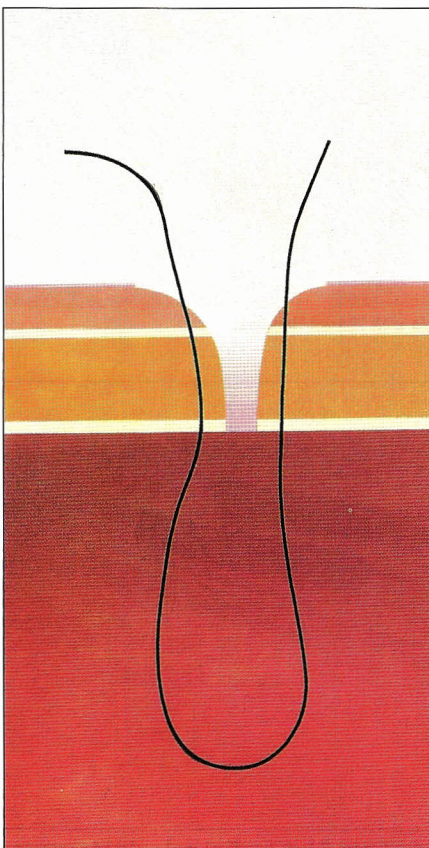
Figure 7a.

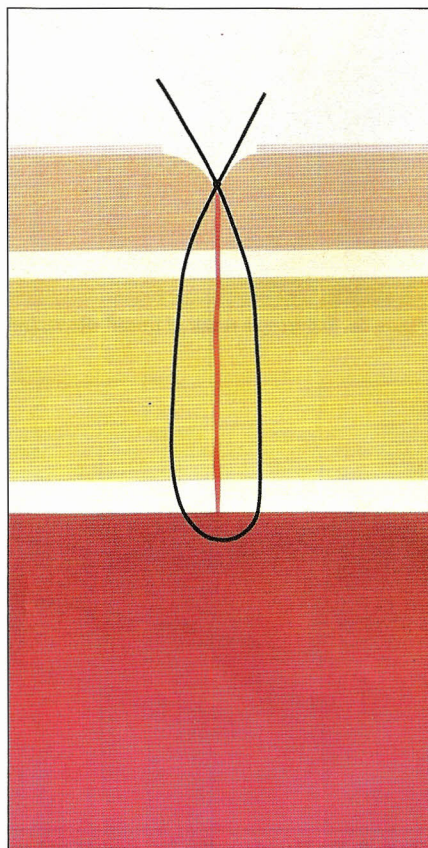**Figure 7b.**

Figure 7c.

Figure 7d.

gulation of a loop of jejunum at the level of a 12 mm trocar wound in the left lower quadrant. Small bowel resection was needed.

b: Three months after unilateral laparoscopic inguinal hernioplasty, a middle age male presented with acute pain and incarcerated ventral hernia at the site of a 12 mm trocar wound in the left lower abdomen. Laparoscopy was done in view of a contralateral hernia, with finding of incarcerated omentum (Figures 4 a,b,c). The repair was done endoscopically.

c: A case similar to 5-b presented six months after repair, without acute symptoms. This patient underwent endoscopic repair of the contralateral hernia and of the trocar's ventral hernia, with omentum present within the sac (Figures 5 a,b). The repair was done endoscopically (Figure 5 c).

PREVENTION AND TREATMENT OF COMPLICATIONS

Most wound infections are related to wound contamination during removal of the appendix or gallbladder. They normally respond promptly to opening of the skin closure, antibiotics and local care. Necrotizing fascitis has been described following laparoscopic procedures[3], and deserves a much more aggressive local and systemic treatment.

The use of extraction bags for removal of grossly contaminated organs (appendix, gallbladder, etc.) may reduce even further this rare event.

All trocar wounds have been treated as laparotomic wounds. The size of the patient's abdominal wall and the small skin incision have at times limited the closure: more than desired and less than expected.

The case described in 6-a was instrumental in finding a better and reliable way to close completely the trocar wounds. After several unsuccessful attempt with the use of long or short straight needles and insertion

Figure 7: a. The curved introducer is used to pass the suture inside the abdomen. The introducer is slightly withdrawn to loosen the suture. **b.** The suture is grasped, while the introducer is removed. The retriever ("golden retriever") is inserted on the opposite side of the trocar wound and grasps the suture. **c.** The retriever is removed, pulling the suture in the subcutaneous tissue. **d.** The suture is tied. (Courtesy of Core Dynamics, Inc.)

through empty needle sleeves, a new system was devised, capable to easily and quickly allow the controlled positioning of as many needed vertical mattress sutures to completely close the abdominal wall from the subcutaneous tissue to the peritoneum: the Maciol Needles (Figure 6).

The "introducer" needle (needle with the eye) is used to pass the suture material (absorbable), through the abdominal wall, into the peritoneal cavity from the subcutaneous tissue (Figure 7 a; Figure 8 a).

The "retriever" needle (needle with the barb) is then passed into the abdomen on the opposite side of the defect, the suture is retrieved and pulled through the tissue (Figures 7 b,c; Figure 8 b). The vertical mattress suture is then tied within the subcutaneous tissue (Figure 7 d; Figure 8 c); the skin is closed and the defect has had a controlled suture.

One vertical mattress suture is usually required and can be placed in a few seconds; occasionally more sutures are required and easily placed either with intraperitoneal assistance (grasper) (Figures 7 a-d; Figures 8 a-c) or by simultaneous use of the two needles: curved introducer and retriever (Figures 9 a,b).

All larger trocars' sites have one suture applied prior to their withdrawal; retrieval of the trocar and tying of the suture are achieved within a matter of seconds.

The suture ought to be placed as close as possible to the trocar wound to decrease the postoperative sense of local tension. The use of permanent suture material is not recommended. During the early phase of our experience three sutures had to be removed under local anesthesia, with complete resolution of the persistent local tension/pain.

This technique does not require any enlargement of the skin incision and the proper closure of the trocar wound is not affected by obesity. Routinely employed for any site with trocar 10 mm or larger, has been used successfully several times for 5 mm trocar wounds, whenever complete closure of these wounds was warranted (e.g.: bleeding, ascites) (Figure 10). Small hernia defects have also been repaired with this simple and effective technique (Figure 5 c).
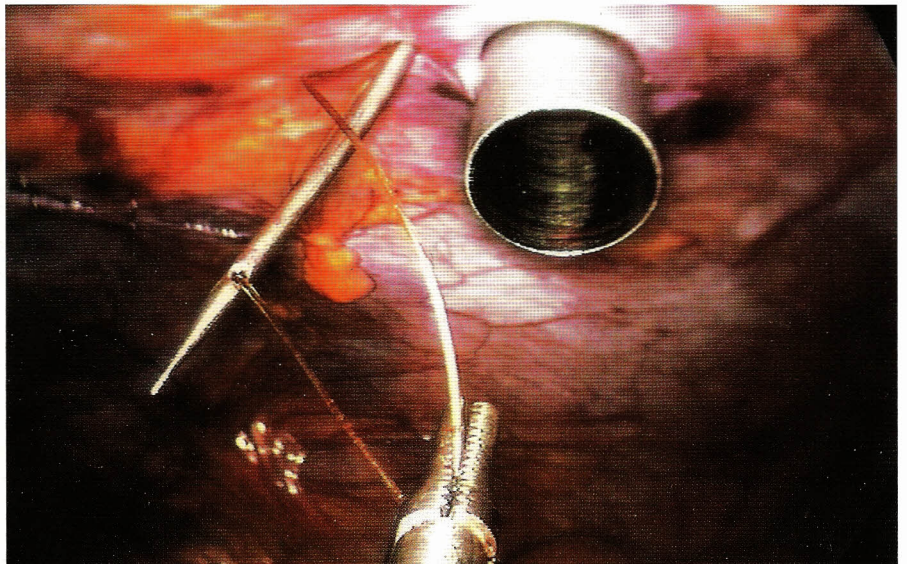

Figure 8a. The introducer needle carries the suture inside the abdomen under endoscopic guidance.

Figure 8b. After grasping the suture, the introducer is removed. The retriever needle is placed on the opposite side of the trocar wound and hooks the suture.

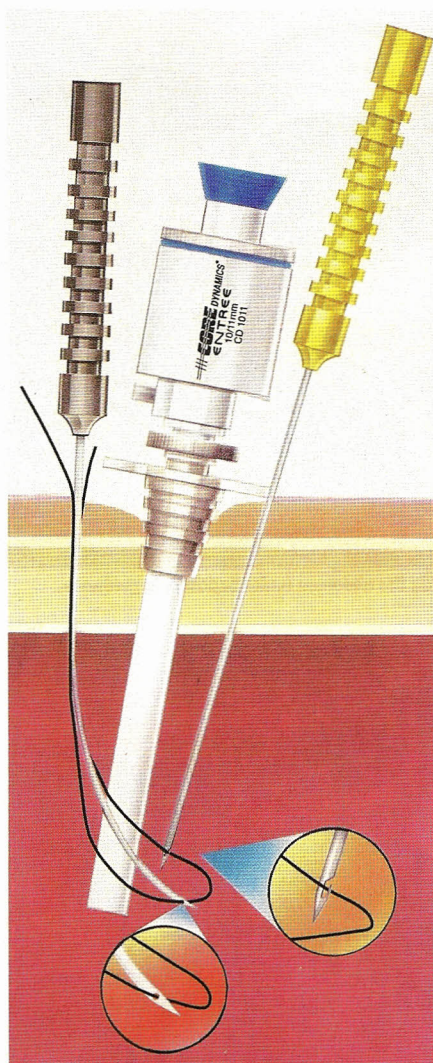Figure 8c. The vertical mattress suture is ready to be tied.

Figure 9a.

Figure 9a (left): Schematic view of the unassisted placement of a vertical mattress suture at a trocar wound' site. (Courtesy of Core Dinamics,Inc.). Figure 9b. (above): The curved introducer carries the suture inside the abdomen, the retriever grasps the suture and both needles are simultaneously removed, placing a controlled vertical mattress suture. This second suture is applied after all but one trocar have been removed.

Figure 10: Closure of 5 mm trocar wound with the Maciol Needles for bleeding control during a cholecystectomy.

CONCLUSIONS

Most commonly the trocar' site of introduction is secured only by withdrawal of the trocar and closure of the most accessible layers of the abdominal wall. Albeit easier in thin patients this closure is in general quite difficult, and rarely complete, due to the small opening of the skin incision: usually not longer than the diameter of the trocar used (5-12 mm).

Personal experience with three cases of hernia formation, one with small bowel strangulation, at the site of 12 mm trocars have led me to find a secure way to achieve complete closure of the abdominal wall wound.

The Maciol Needles (Core Dynamics, Inc.) (Figure 6) have been used for three years for this purpose, without recurrence of the problem.

More than one suture can be applied with this technique in a short time, under direct vision and endoscopic guidance. Moreover this same technique has been used to secure bleeding from both large and small trocar wounds without problems, as well as for repair of small ventral hernias.

Respect for prudent surgical principles and for the patient, besides the potential for medical complications and legal entanglements, should lead to the complete closure of all trocar wound with diameter of 10 mm or more.

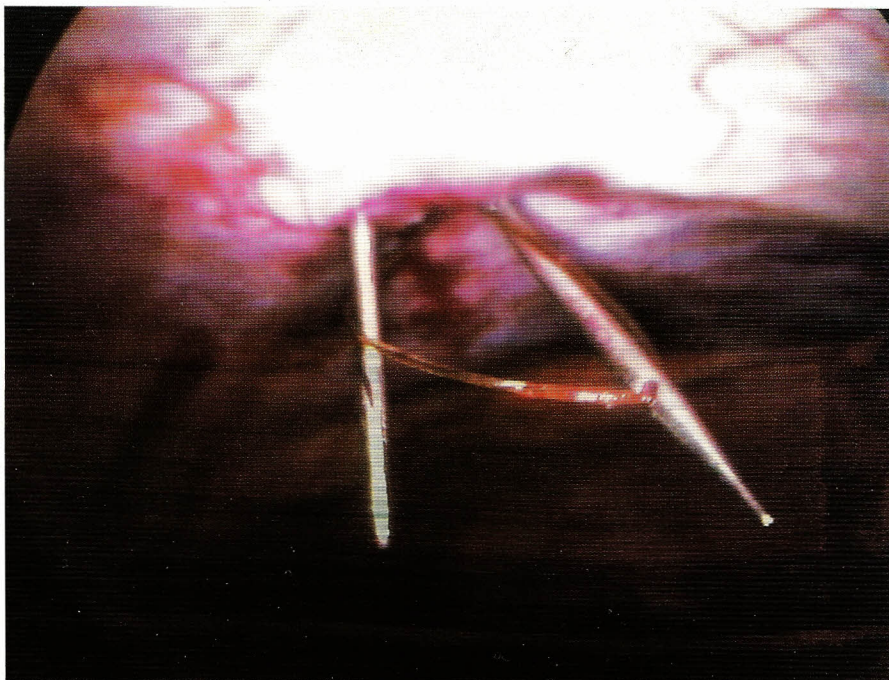Surgical control, rather than chance should prevent complications at trocars' sites. ■

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