Sonographic Trocar

Narrative

1. ABSTRACT

The sonographic trocar is a device for the initial abdominal entry during laparoscopic surgery. The device consists of a combined light source/camera chip/ultrasound probe housed in the tip of a 12 mm trocar. Using a split-screen monitor that shows the camera and ultrasound image simultaneously, the surgeon can monitor the progress of the trocar tip as it passes through the abdominal wall and into the abdominal cavity. The intention of the device is to reduce the risk of trocar injury to the viscera during the initial abdominal entry.

2. BACKGROUND

In order to perform a laparoscopic operation, the abdominal cavity needs to be insufflated with CO_2, which provides a working space (also known as pneumoperitoneum) to perform the procedure. The insufflation of the abdominal cavity requires that some sort of access to the cavity is obtained. Typically this is done in one of three ways: (1) insertion of a Veress needle, which is a long, 14 gauge metal tube with a penetrating tip; (2) insertion of a trocar with an optical "bladeless" tip, such as that pictured in Figure 1; or (3) the so-called "open" technique, in which the surgeon makes a small (2-3 cm) skin incision, and attempts to get into the abdominal cavity with dissection under direct visualization. The first method requires the blind insertion of a pointed instrument into the abdominal cavity, which carries a risk of injury to the intraabdominal viscera. The second method, which uses a trocar of the type in Figure 1, is unique in that the laparoscope is placed inside the trocar during the insertion of the trocar through the abdominal wall. With this method, the surgeon can view the advancement of the trocar tip through the abdominal wall layers on the monitor. The tip of the trocar is "bladeless;" it separates the tissues more than actually cutting them (but the tip still can puncture bowel or major blood vessel). Initially it was thought that the second method would sharply curtail trocar injuries, but this has not been the case.[1] The third (open) method can be difficult because of the exposure problems with a small incision, especially if there more than 2 cm of subcutaneous fat. Injury can occur to the intraabdominal viscera (e.g., intestinal perforation) with any of these methods even in the most experienced of hands.[1-4] This type of injury can be serious, and even fatal. The inventor of the proposed device (MAC) has incurred a trocar injury during a laparoscopic procedure that he has performed, and he also served as expert witness on malpractice suits involving trocar injuries. In fact, the inventor would be hard pressed to name an established laparoscopic surgeon who has *not* had such an injury.

3. STATEMENT OF NEED

Currently there is no device which adequately addresses the need for a safe method of abdominal entry during a laparoscopic operation. The field of laparoscopic surgery needs a device which can enter the abdominal cavity safely for the creation of a pneumoperitoneum. Some devices have been produced which claim to fulfill this role; e.g., the AutoSuture™

VISIPORT™ PLUS optical trocar, which essentially is a modification of the trocar type shown in Figure 1. None of these newer devices appear to reduce the risk of trocar injury, though;[1] in fact, the most recent medicolegal case in which the inventor was an expert witness involved a trocar injury from a VISIPORT™ device. Interestingly, Some investigators have noted that the performance of an ultrasound (using conventional equipment) at the proposed site of entry into a body cavity can reduce the risk of injury to internal structures.[5-7] So it is conceivable that a trocar which incorporates ultrasound technology might be useful for reducing the risk of visceral injury during the initial abdominal entry for a laparoscopic procedure. An internet search on October 10, 2007 by the inventor did not discover any preexisting publications, patents, web pages, etc. which would indicate that such a device has been built, described, or proposed.

4. OVERVIEW OF THE PROPOSED SONOGRAPHIC TROCAR

The proposed device (Figure 2) currently is a concept only; a prototype of the sonographic trocar has not been built. The proposed device has an appearance similar to the optical trocar shown in Figure 1; the device in Figure 2, however, contains a combination camera chip/ultrasound probe/light source (the sensor) in the tip of the obdurator. The sensor permits simultaneous camera and ultrasound images to be transmitted to the monitor. The surgeon thus can view the progress of the trocar tip with the camera as the tip passes through each layer of the abdominal wall, while viewing (and avoiding) the underlying viscera with the ultrasound probe, as shown in Figure 3.

5. UTILITY OF THE PROPOSED SONOGRAPHIC TROCAR

Establishment of pneumoperitoneum is required in virtually all laparoscopic procedures. Complications from abdominal insufflation has occurred in all types of abdomens, from those which have had multiple procedures (and which presumably have multiple intraabdominal adhesions that increases risk for injury) to those which have never been operated. Therefore, a trocar which has improved safety over those in current use would be applicable to virtually all laparoscopic procedures, which is a huge potential market for the proposed sonographic trocar.

6. DETAILED DESCRIPTION OF THE PROPOSED SONOGRAPHIC TROCAR

The outward appearance of the sonographic trocar (Figure 2) is similar to the conventional trocar shown in Figure 1. The sonographic trocar consists of an outer sleeve and an inner obdurator. At the tip of the obdurator is a sensor unit which contains a light source that derives power from the cable that exits from the top of the device. The sensor also contains a camera chip which provides a visual image of the forward path of the trocar. In addition, the sensor contains an ultrasound probe which transmits images of the structures that lie beneath the tip and which are not visible by the camera. The inner diameter of the trocar is 12 mm, which is adequate to pass most of the currently available laparoscopic instrumentation.

To gain entry into the abdomen for insufflation and creation of pneumoperitoneum, a small skin incision is made with a scalpel. The sonographic trocar is inserted through this skin incision (Figure 3). Using a twisting motion combined with steady downward pressure, the surgeon slowly pushes the trocar through the layers of the abdominal wall. The optical bladeless tip of the sonographic trocar is similar to the tip of the conventional trocar shown in Figure 1. An

optical bladeless trocar passes through tissue more by separating the tissue layers and less by cutting them.

The camera chip in the sensor of the sonographic trocar (Figure 3) transmits video to an external split-screen monitor. The surgeon thus can observe the tip of the sonographic trocar as it penetrates through each layer of the abdominal wall. The sensor also transmits ultrasound video to the split-screen monitor. So in addition to a visual image of the tissue which is in immediate contact with the trocar tip, the surgeon also obtains an image of structures which are deep to the trocar tip, such as loops of bowel, large blood vessels, solid organs, etc. If the surgeon perceives on the ultrasound window that the tip of the trocar may penetrate an intraabdominal organ, then the surgeon can redirect the sonographic trocar so that the penetration does not occur. With the forward view of a camera only (e.g., with the trocar in Figure 1), the surgeon sees the penetration only after it has occurred.

It is likely that the sonographic trocar will be relatively costly compared to a conventional trocar, because of the sensor unit in the former. Therefore it may be appropriate to construct the obdurator of the sonographic trocar as a reusable unit. The sleeve would be a single-use device, and packaged separately. Such a strategy should keep the utilization cost of the sonographic trocar under control.

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7. REFERENCES

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8. FIGURE LEGENDS

Figure 1. Images of an optical bladeless trocar for laparoscopic surgery (ENDOPATH® Xcel™ Bladeless Trocar from Ethicon, Inc.).

A. Trocar fully assembled. Length of the unit is ~19.5 cm.
   1. Optical bladeless tip of trocar
   2. Insufflation valve
   3. Release button to remove obdurator from sleeve
   4. Locking tab to hold laparoscope in place

B. Trocar disassembled.
5. Obdurator component
6. Sleeve component (inner diameter = 12 mm)
7. Location where laparoscope is inserted

C. Close-up view of optical bladeless tip
8. Noncutting tip is relatively dull, but still can penetrate hollow structures.

Figure 2. Diagram of the proposed device, the sonographic trocar. The device has approximately the same dimensions as the trocar shown in Figure 1. Embedded near the tip is the multi-functional sensor which provides illumination and houses the camera chip and ultrasound probe.

Figure 3. Sonographic trocar in use.

A. Close-up of the tip of the sonographic trocar as it penetrates through the layers of the abdominal wall
1. Dermal layer of the abdominal wall
2. Subcutaneous fat layer of the abdominal wall
3. Anterior fascial layer of the abdominal wall
4. Muscular layer of the abdominal wall
5. Posterior fascial/peritoneal layer of the abdominal wall
6. Tip of sonographic trocar
7. Sensor
8. Sensor cord within obdurator
9. Loops of intestine in cross section

B. Visual and sonographic images from sensor are transmitted to the monitor
10. Split-screen monitor
11. Camera window
12. Ultrasound window

Figure 1

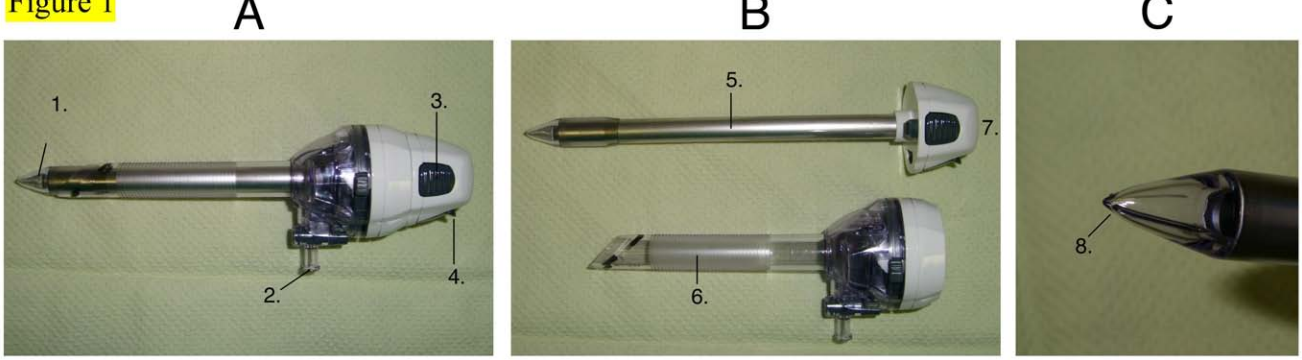

Figure 2

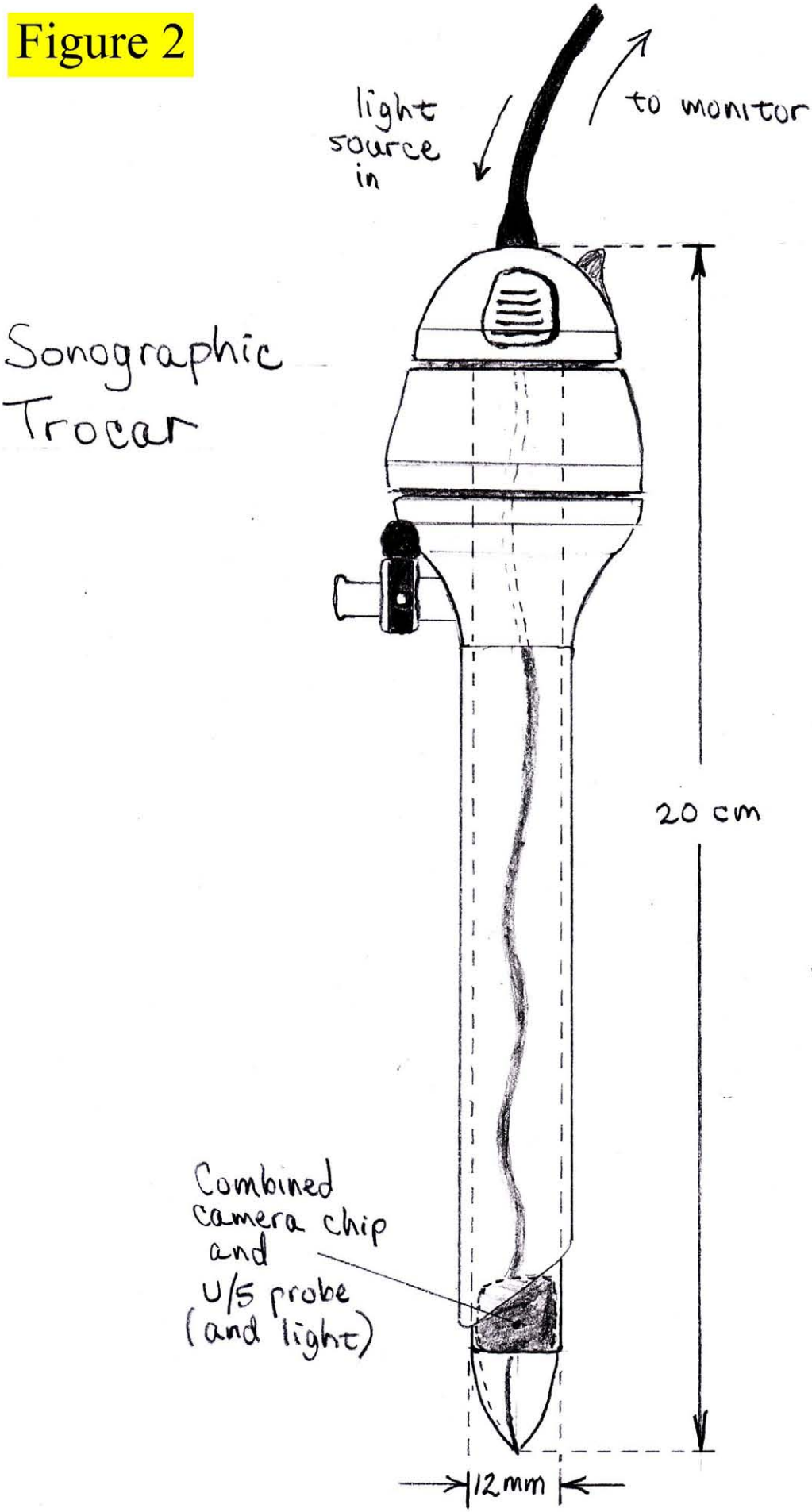

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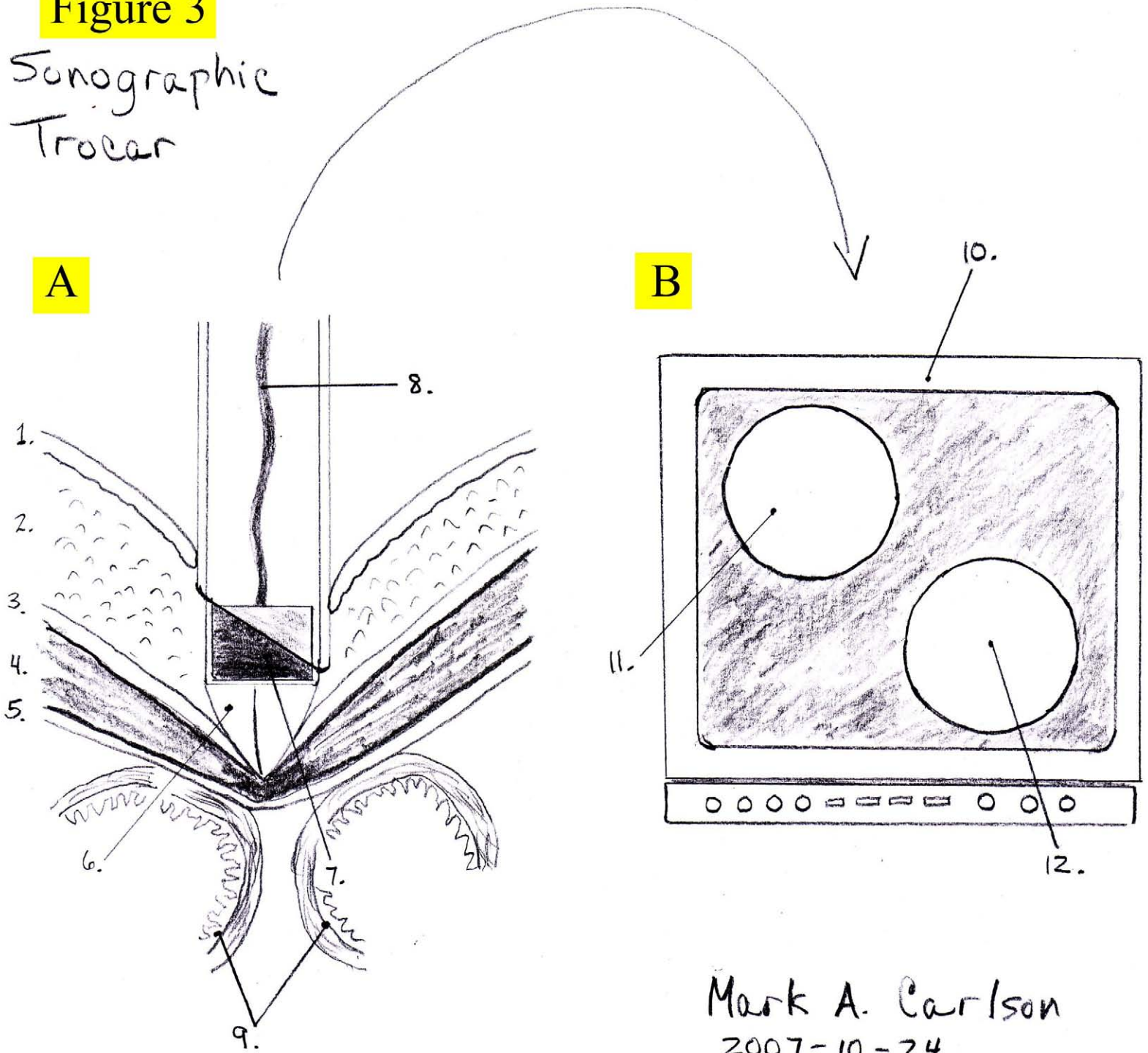
Figure 3

Sonographic Trocar



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