Sewing Machine in Urologic Surgery

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Abstract

Introduction: Although mechanical sutures represented a before and an after in digestive surgery, their use in urology is greatly limited by the risk of stone disease and chronic infection. Accordingly, in laparoscopic cystectomy, the intestinal time is still usually done by hand extra-corporeally. Even using a robot, sutures are still slow and imperfect, varying in tension, symmetry and separation between stitches. It is therefore expected that, little by little, they will become independent from human control.

Methods: We used a small sewing machine available on the market to undertake an experimental study in pigs. In one group of animals we separated the bladder into two valves which we then sewed together. In the other group we performed a cystoplasty with the cecum.

Results: We determined that these sewing machines can be used with living tissue with no need to manufacture a complicated and expensive prototype. Although we experienced a series of technical mishaps, we were able to perform the sutures successfully, achieving complete tightness. The operative times were good despite testing a new instrument for surgery.

Conclusion: Sewing machines can be used with biocompatible material. Surgical robots, although in existence for over 20 years, are still unable to automate the suture process, whereas sewing machines are more precise, predictable and can even be considered a small robot. Nevertheless, these machines still require great modifications before they can give guaranteed sutures in living tissue.

Keywords: Sewing machine; Mechanical suture; Cystoplasty; Robotic suture

Abbreviations

SSQ: Stitch Sew Quick; HS: Handheld Sewing machine

Introduction

Mechanical sutures have been used for over a hundred years. Although rechargeable cartridges were available in the 1960s, their use did not become generalized until the 1980s, when they developed rapidly, progressing greatly. However, since then they have changed little and no really important innovations have taken place, as witnessed by the lack of new literature [1]. Mechanical sutures resulted in enormous progress in the field of digestive surgery, so much so that we can speak of a before and an after. However, in urology, their use is still quite limited, with the exception of just ligation of the renal vessels or intestinal anastomosis after cystectomy. Previously, staples were used for urinary diversions, but the high risk of formation of calculi and chronic infections discouraged their use [2,3]. Accordingly, in laparoscopic or robotic cystectomy, the intestinal time is still usually done by hand extra-corporeally, given its difficulty in most cases [4].

With a machine the sutures are instantaneous and perfect. However, when they are done by hand during surgery, they are hardly flawless, as they are slow and there is variation in tension, symmetry and inter-stitch separation. Surgical robots have been in existence for over 20 years. They are referred to as advanced tools since they possess a master-slave arm, but as the stitches are given by hand, they are never exact. Thus, although we may not always be aware of it, surgical sutures are inevitably imperfect. Accordingly, it is hoped that in the not-too-distant future the process will become automated and much less dependent on the surgeon.

Material and Methods

We undertook an experimental study using two models of mini-sewing machines. They are...
sufficiently small to work inside the operative field (Figure 1). One is called the “Stitch Sew Quick” (SSQ) and the other the “Handheld Sewing machine” (HS).

**In vitro study**

We first undertook an *in vitro* study using chicken skin from ten half chickens. After making an 8 cm long incision in the skin we machine sewed along one of the edges. For the next test we made an 8 cm long fold in the skin and then sutured it from end to end. Finally, we made an 8 cm long incision and sutured it from edge to edge. Each test involved six or seven incisions.

At first sight the SSQ seemed more attractive, mainly because it was smaller and apparently more ergonomic. However, it only worked well with the sutures in single skin. When we attempted to sew two layers of skin or two edges the machine failed to progress and became stuck. As far as we could tell this was because the distance between the needle and the tissue was much less with the SSQ than the HS, so there was hardly space to insert the tissue.

This prior *in vitro* study proved very useful as it enabled us to select the HS machine as the most suitable before proceeding to the experimental stage.

**Experimental animal study**

The experimental protocols were approved by the institutional ethics committee. Six female “Large White” pigs were used, weighing 35 kilos. The animals were administered Telazol 4.4 mg/kg, Ketamine 2.2 mg/kg and Xylazine 2.2 mg/kg for induction of anesthesia. During the procedure the anesthesia was maintained with Isofluorane 3%. There was no follow-up and at the end the animals were euthanized.

The HS machine, like most others of this type, uses a single thread and not two like conventional machines. That is, it makes a continuous suture with a single thread, as is done in surgery, known as chain stitch.

In six animals we made a transverse incision along the whole bladder, opening it up in two valves, like a clam, and then machine sewed it. In the other six animals we undertook an augmentation cystoplasty using the cecum.

**Opening the bladder in two valves and machine sewing:** The bladder is approached via a laparotomy. In these animals the bladder is very accessible and not at the bottom of the pelvic floor, as in human adults. A transverse incision is made in the bladder from the dome almost down to the trigone on each side [5]. Stay sutures are given, one in the dome and another at each end of the incision. As catheterization is difficult, we insert a retrograde catheter from the bladder to the exterior, tie a Foley, pull back and inflate the balloon. We used female animals precisely because catheterization is easier.

We lubricate the fastening plate, so that the tissue can slide easily over the plate (Figure 2), and use Vicryl Suture 4-0 Polyglactin 910. First, we stretch the two edges to be sutured to bring them close together. Under normal conditions using cloth the machine pushes the cloth along as it sews, but here we have to pull the tissue. This pulling should not be too fast or the stitches will be too far apart and the seal will not be hermetic. On the other hand, if the pulling is too slow the stitches will be very close together, forming a ball of thread under the needle, jamming the machine.

First, we suture the left hemi-bladder. The length of this hemi-suture is 8 cm to 9 cm. We then suture the other side similarly, from the dome to the right extreme (Figure 3). This ends the procedure.

**Augmentation cystoplasty with sewing machine:** After inserting a catheter as above, we approach the bladder and give two stay sutures slightly above the trigone, one on each side. Here we section and...
excise the whole upper part of the bladder, such that it is then shaped rather like a bowl [6].

We isolate the cecum together with its vascular pedicle. The ileum is not an impediment because in these animals it empties higher up. We wash the cecum well and place it around the edges of the remaining open bladder, giving a reference suture on either side. In pigs the bladder is very high so the cecum reaches it easily. This gives us two suture planes, one anterior and the other posterior, which are sutured exactly the same as described above, not forgetting to lubricate the machine first so that the tissues can slide well. The total length of each hemi suture is around 6 cm to 7 cm (Figure 4).

Results

In the first group, in which we just sutured the bladder, we were able to perform a continuous suture along the whole incision.

In one case, after stitching half the bladder, the suture became completely undone because the sewing machine had been too close to the edges. This presented no problem and we did it again uneventfully.

Even though we were testing a new device in living tissues, the procedure times were good, maybe even better than doing it by hand.

These machines are designed so that each suture measures 3 mm. As the total length of the incision to be sutured in the bladder is 16 cm to 18 cm, the overall number of stitches given was somewhere between 50 and 60. These stitches were all inserted quickly and precisely, and would take a long time to do by hand.

In the second group we were also able to suture without problems, probably with more assurance as we had some experience. The posterior suture of the cecum to the bladder presented no special difficulty. On inspection, the suture was not bleeding and did not appear to result in any ischemic changes, as the coloration of the surrounding tissues was good.

In this group, however, we had a series of technical mishaps shown in Table 1. In one incident the needle became unthreaded. Although this resulted in loss of time, retreading was quick thanks to the threader, which is a spindle-shaped wire that is passed through the eyelet (Figure 1). On another occasion the machine stopped and we had to change the batteries. Another time the carcass covering the needle arm fell apart but we were able to reassemble it. Another technical incident involved the needle becoming dislodged. We were able to locate it and replace it, tightening the screw that holds it in place (Figure 1). In no case did the needle break, which is a possibility to consider so that spare needles must always be available.

Discussion

Sewing machines have only been used in surgery on a few occasions, so the literature is scarce. One case used a conventional table-top machine making the intestine reach it, which for obvious reasons has great limitations [7]. A prototype of a smaller sewing machine exists, also for use on the intestine [8,9], and more recently another study compared in vitro machine sewing with hand sewing [10].

Various types of small sewing machines are available commercially. These can be held in one hand and use just one thread, which simplifies them greatly. We chose these machines because, in theory, we do not have to design and manufacture a tool to test what is certainly a novel technique. These machines are designed to sew clothes and our aim was to show that they can also be used with living tissue.

In this study we used, for the first time, a sewing machine in actual urological surgery, first to suture the bladder and then to perform an augmentation cystoplasty. We did the cystoplasty with large intestine because in an earlier attempt we used the small intestine but found that the roughness and thickness of the ileal mucosa made it difficult to introduce it into these machines.

The bladder has sufficient consistency to enable it to be sown with no problems whereas the small intestine is easily torn with these machines. The large intestine, on the other hand, can be easily sutured because its surface is smooth and it slides better.

Under normal conditions of a sewing machine the cloth moves by itself, drawn by feed dogs (a sort of toothed rod sticking up through a slit in the platform where the cloth lies). With biological

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tissues this movement does not occur and the tissue has to be drawn smoothly by hand. This dragging has to be done at a suitable speed because if it is too fast the stitches are very long and not hermetic. If the pulling is too slow, however, a sort of knot is created beside the needle and the machine becomes blocked. It should be recalled that the machines are designed so that each stitch measures 3 mm. To facilitate this displacement of the tissue we found that it is necessary to place lubricating gel on the sewing machine and on the tissue to be sutured. When we failed to do this at the start of the study it was very difficult to suture. We also had various setbacks which are not surprising because the machines are not designed to work in these conditions and they are functioning almost at maximum.

Normally in surgery when a continuous suture is finished it is necessary to tie a knot to stop it becoming loose. In the textile industry, however, a knot is not made and at the end a few stitches are given right beside each other and the thread is cut (finishing the seam). Machines with just one thread, like that we used, have the inconvenience that this knot has to be tied at the end, just like in surgery, or else the seam has to be finished by inserting more stitches at the end.

In the past absorbable mechanical sutures were tried in the bladder. However, they are no longer used as they lacked consistency, became easily detached and also involved the same risk for the formation of calculi and infection as metallic sutures. The main advantage of sewing machines, therefore, is that they can be used with absorbable stitches, thus enabling a better adaptation of the tissues, as well as having a uniform suture pattern, independently of the skills of the surgeon, making them more reliable.

Although surgical sutures data back thousands of years the main principles have remained almost unchanged, as they are still given by hand using thread and a curved needle. Surgical robots, though in existence for over 20 years, are still unable to automate the suture process. In fact, seams made with a sewing machine are more precise, the tension of the thread is constant, and they are predictable and reproducible.

**Conclusions**

These commercially available sewing machines are small and enabled us to easily try suturing living tissues with no need to design a complicated and expensive prototype.

Sewing machines enable us to give dozens of stitches in seconds with great precision and no particular difficulty.

They can be used with biocompatible material, thus providing better tissue coaptation and suture firmness.

As sewing machines are semi-automated, they are a sort of robot in themselves, since they transform an analogue process to a digital process. This may lead to a true revolution because the movement can be quantified [11].

You just have to see the speed and perfection of a sewing machine to realize the abyss that separates us. We are convinced that in the not-too-distant future they will be in general use in surgery. Beforehand, though, they will need great modifications and the time needed to guarantee sutures in living tissues.

**Acknowledgement**

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