

A comparison between laser-welded and conventionally sutured ileocystoplasty in rats

J. STEINBERG MD, L.A. WILSON DVM, R.A. BALL MD &
K.R. LOUGHLIN MD

Harvard Program in Urology (Longwood Area) and the Brigham And Women's Hospital, Boston, Massachusetts, USA

Summary. Operative and histological characteristics of laser-welded and conventionally sutured ileocystoplasties were compared in a rat model. Ileocystoplasties, using the operating microscope, were performed on rats divided into three surgical groups. An enteric patch of detubularized ileum was sutured to the bladder in all groups using six stay sutures. In the first group, the carbon dioxide laser was used to seal the serosa of the ileum to the bladder serosa (laser-welded group). A second group underwent circumferential placement of continuous suture (conventional group), while the third group had no additional sutures placed (stay suture group).

Average operating time was lowest in the stay suture group and laser-welding was not significantly longer than conventional suturing. Duration of post-operative leakage by cystogram was similar in all three groups and averaged 5-6 days. The incidence of foreign body reaction was lowest in the stay suture group, but similar in the laser-welded and conventionally sutured groups. The rate of gross stone or sludge formation was lowest in the laser-welded group compared to the conventionally sutured and stay suture animals. Microscopic abscess formation was also lowest in the laser-welded group compared to the conventionally sutured and stay suture groups.

This study suggests that laser-welded ileocystoplasty may be a useful technique of bladder augmentation, comparable to conventionally sutured anastomosis in this animal model. Laser-welding may offer the additional advantages of decreased stone, sludge and microscopic abscess formation.

Keywords: laser, bladder, augmentation

Introduction

Bladder augmentation utilizing intestinal segments is a well-established technique for increasing bladder capacity in neurogenic, inflammatory and neoplastic conditions. However, enterocystoplasty is often a lengthy operative procedure which may be complicated by prolonged leakage of urine, stone or abscess formation and foreign body reaction. The carbon dioxide laser has been described as

a new tool for performing improved anastomoses via its welding action on tissues in gastrointestinal and genitourinary surgery [1-4]. We performed a study in rats to compare the operative and histological characteristics among laser-welded ileocystoplasties, conventionally sutured anastomoses and animals undergoing stay suture placement only.

Materials and methods

Forty female Sprague Dawley rats, weighing 275 g each, were divided into three surgical groups. After induction of anaesthesia with inhalational ether and intraperitoneal

Correspondence: Dr J. Steinberg, Division of Urology, Brigham and Women's Hospital, 45 Francis Street, Boston, Massachusetts 02115, USA.

chloral hydrate (360 mg/kg), the skin was prepared with ethyl alcohol. With the use of a Storz Urban operating microscope, via a midline incision, an 8 mm segment of ileum was isolated with its vascular mesentery intact. After ileal reanastomosis using interrupted 6/0 polyglycolic acid sutures, the ileal segment was incised along its antimesenteric border and fashioned into a 6 × 8 mm rectangular or triangular patch. The bladder was then exposed and an 8 mm circular area of the dome was excised. In all surgical groups, the ileal patch was sewn to the bladder using six 6/0 polyglycolic acid interrupted stay sutures. In the laser-welded group, an ILMed Unilase (Walpole, Massachusetts, USA) carbon dioxide laser was used to weld the serosa of the ileum to the bladder serosa. Using a power of 0.13 watts, a spot size of 0.5 mm, on a repeating mode of 0.5 second intervals, the laser beam was applied along the anastomotic line until the tissue edges turned grey-white and sealing of the two serosal edges was achieved. In the conventionally sutured group, a continuous 6/0 polyglycolic acid suture was placed in a circumferential manner. In the stay suture group, no additional sutures were placed nor was the laser utilized. After completion of the anastomosis, the abdominal muscle and fascia were closed with 4/0 polyglactin suture and the skin was closed with 4/0 silk suture. Operative time was recorded for each rat. Post-operatively, the rats were immediately returned to diets of rat chow and water.

Cystographic study

Cystograms were performed under anaesthesia from 1 to 12 days post-operatively. After administration of intramuscular xylazine (12 mg/kg) and ketamine (0.6 mg/kg), the urethra was catheterized with 0.038 inch polyethylene tubing and advanced gently until urine was obtained. Nine tenths of a millilitre of 60% diatrizoate meglumine and sodium contrast solution was gently instilled using a 1 ml tuberculin syringe. The catheter was then withdrawn and radiographs in the anteroposterior and right lateral decubitus positions were taken with a Faxitron (McMinnville, Oregon, USA) X-ray unit at 32 k.v.p. at a 48 s exposure time. Radiographs were then examined for evidence of contrast extravasation.

Histological study

Animals were killed at 1, 2 and 4 weeks after surgery and the augmented bladders were removed *en bloc* and examined for gross stone and sludge formation. Following fixation in formalin, three longitudinal sections were taken from each anastomosis and embedded in paraffin. After microtome processing and staining with haematoxylin and eosin, each anastomotic section (Figure 1)

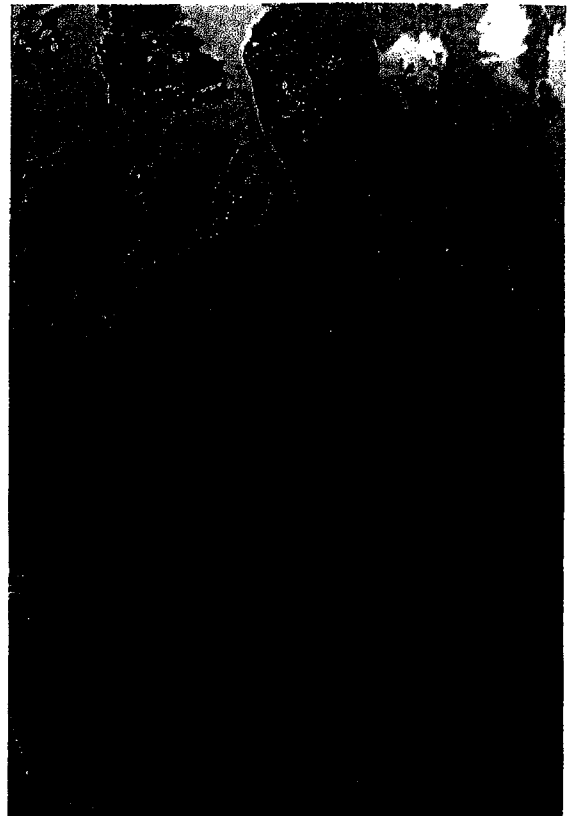


Figure 1. Microscopic appearance of laser-welded ileocystoplasty specimen — arrow denotes area of anastomosis between ileal mucosa (left) and bladder mucosa (right). H & E. × 200.

was examined for the presence of foreign body granuloma and microscopic abscess formation.

Results

Five laser-welded rats, one conventionally sutured rat and five stay suture rats died prior to the planned date of killing. Four of the five laser-welded rats died in the first 24–36 hours after surgery without regaining spontaneous movement and these deaths were attributed to the anaesthetic. The fifth laser-welded rat died on post-operative day (POD) 7 after demonstrating persistent leakage by cystogram on POD 5. One rat in the conventionally sutured group died immediately after cystogram on POD 4 which demonstrated no leakage; the death was felt to be secondary to the xylazine and ketamine anaesthetics. Five rats in the stay suture group died from 1/2 to 2 days after surgery; two rats in this group never recovered from anaesthesia. Of the other three rats in this group, one

demonstrating the availability after s

The days functional group leakage time minutes operative conventional

After sludge while 3/9 (3 stone Test).

bladder rates the laser group lowest formation group as compared (P =

Disc

The c as ar

Table

Laser-Conve Stay s

By F

Table 1. Operative and cystographic results

	Operated	Died	Evaluable	Average operation time (min)	Leakage duration
Laser-welded	16	5	11	77.9	6.1 days
Conventional	11	1	10	75.2	5.5 days
Stay sutures	13	5	8	58.7	5.6 days

demonstrated persistent leakage on cystogram. Excluding these 11 rats that died prematurely, 29 rats were available for full radiographic and histological evaluation after surgery.

The average duration of leakage by cystogram was 6.1 days for the laser-welded group, 5.5 days for the conventionally sutured group and 5.6 days for the stay suture group. These differences in duration of post-operative leakage were not statistically significant. Mean operative time was shortest for the stay suture group at 58.7 minutes, while the laser-welded group with an average operative time of 77.9 minutes was comparable to the conventionally sutured group which averaged 75.2 minutes (Table 1).

After killing, visual inspection revealed gross stone or sludge formation in 2/11 (18%) of the laser-welded rats, while 5/11 (45%) of the conventionally sutured group and 3/9 (33%) of the stay suture animals had intraluminal stone or sludge formation ($P = 0.27$ by Fisher's Exact Test). Sections were examined from each augmented bladder in consultation with a staff pathologist. Similar rates of foreign body granuloma formation were found in the laser-welded group (6/11 - 55%) and the conventional group (6/10 - 60%) while the stay suture group had the lowest rate (3/8 - 38%) ($P = 0.28$). Microscopic abscess formation was more prevalent among the conventional group (3/10 - 30%) and the stay suture group (3/8 - 38%) as compared to the laser-welded animals (2/11 - 18%) ($P = 0.32$) (Table 2).

Discussion

The carbon dioxide laser has been previously described as an effective tissue-welding tool for skin, nerves, fal-

lopian tubes, and blood vessels. In addition, this laser has been employed to produce water-tight anastomoses with enhanced tissue healing in a variety of urological surgeries.

Vasovasostomies, utilizing the carbon dioxide laser, have been performed in an animal series resulting in semen-tight anastomoses, a low incidence of sperm granulomas and high luminal patency rates [1]. A recent series of laser-welded anastomosis of the vas in humans yielded sperm-containing ejaculates in 95% of men who had undergone vasectomy less than 10 years prior to reversal [2]. Similarly, patent urothelial anastomoses have been achieved in rabbits undergoing laser-welded non-stented ureteroureterostomy [3]. We found similar durations of post-operative leakage by cystogram in the three surgical groups, suggesting that the healing characteristics of the laser-welded serosa is comparable to conventionally sutured anastomoses.

The histological effects of laser-welding have been extensively studied in a variety of experimental models. Pedicled flap skin tubes constructed in rabbits using the CO₂ laser were microscopically indistinguishable from conventionally sutured tissue in terms of inflammatory response and collagen formation [4]. Similar to our findings, tissue sections from animals undergoing laser-welded vasovasotomy exhibit an acute inflammatory process with foreign body giant cell reaction. This acute inflammatory reaction persisted up to 2 weeks replaced by a predominantly mononuclear inflammatory response by 3 weeks post-operatively [1].

The subcellular characteristics of laser-welded tissue have been examined in attempts to explain the mechanism of the weld effect. First, Jain proposed that fusion of the collagen fibres in the media of vessels produces the welding effect in laser-assisted vascular anastomoses [5]. Serure further theorized that the water-tight bond is produced by thermal coagulation and protein denaturation [6]. Electron micrographic studies of laser-welded carotid arteries have revealed marked interdigitation of the collagen fibrils in the adventitia with a loss of fibril periodicity and increase in caliber [7]. Similar changes in collagen structure may be responsible for the laser-welding effect of our ileo-vesical anastomoses.

Table 2. Gross and microscopic characteristics

	Stone/sludge formation	Foreign body granuloma	Microscopic abscess
Laser-welded	2/11 (18%)	6/11 (55%)	2/11 (18%)
Conventional	5/11 (45%)	6/10 (60%)	3/10 (30%)
Stay sutures	3/9 (33%)	3/8 (38%)	3/8 (38%)
	$P = 0.27^*$	$P = 0.28^*$	$P = 0.32^*$

*By Fisher's Exact Test.

The prevalence of foreign body reaction was similar in the laser-welded and conventional groups and lowest in the stay suture group and was felt to be directly related to the use of suture material in our animal model. Similar observations have been made in laser-welded vascular anastomoses; an exuberant foreign body inflammatory response has been found at the area of suture placement but this response was absent at the area of laser welding within the same vessel [6].

In conclusion, we have found that the carbon dioxide laser is an effective tool for performing ileocystoplasties. Similar operative times, rates of foreign body reaction and durations of post-operative leakage were found in our laser-welded, conventionally sutured and stay suture groups. Laser-welding seems to offer the additional advantages of decreased stone, sludge and microscopic abscess formation in this animal model. Current work with other animal models may confirm that the carbon dioxide laser is a valuable tool in performing a variety of enterocystoplasties.

Acknowledgement

The authors would like to thank Dr Noel Weidner who assisted in the histological evaluation.

References

- 1 Rosemberg SK, Elson L, Nathan LE. Carbon dioxide laser microsurgical vasovasostomy. *Urology* 1985; **25**: 53-6
- 2 Shanberg A, Tansey L, Baghdassarian R, Sawyer D. Laser-assisted vasectomy reversal: experience in 32 patients. *J Urol* 1990; **143**: 528-30
- 3 Merguerian PA, Rabinowitz R. Dismembered non-stented uretero-ureterostomy using the carbon dioxide laser in the rabbit: comparison with suture anastomosis. *J Urol* 1986; **136**: 229-31
- 4 Mininberg DT, Sosa RE, Neidt G, Poe C. Laser welding of pedicled flap skin tubes. *J Urol* part 2 1989; **142**: 623-5
- 5 Jain KK. Sutureless microvascular anastomosis using a neodymium-YAG laser. *J Microsurg* 1980; **1**: 436-9
- 6 Serure A, Withers EH, Thomsen S, Morris J. Comparison of carbon dioxide laser-assisted microvascular anastomosis and conventional microvascular sutured anastomosis. *Surgical Forum* 1983; **34**: 634-6
- 7 Schober R, Ulrich F, Sander T, Durselen H, Hessel S. Laser-induced alteration of collagen substructure allows microsurgical tissue welding. *Science* 1986; **232**: 1421-2

Intro

When th
in the m
lowed b
- at leas
the ther
lithotrip
operatic
only 10-
gall bla

Altho
researc
stone cl
enced &
Novemb
of biliar
the res

England

Thes
in the A
results.
Drug Ac
lithotrip

Corresp
Wave L
hausstre