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An Assessment of a Collagen/Vicryl Composite Membrane to Repair Defects of the Urinary Bladder in Rabbits

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Summary. Collagen/vicryl (Polyglactin) composite membrane has been used to repair full-thickness defects in the urinary bladder of rabbits. The material has been shown to be biodegradable, prevent leakage of urine, and is readily replaced by collagenous scar tissue lined with a urothelium. Regeneration of smooth muscle has been observed in the repair area of some animals. The results suggest that such a material may well be of use to urologists wishing to augment contracted bladders or in the repair of bladder fistulae in human subjects, thereby avoiding the use of bowel or other material e.g. omentum.

Key words: Bladder, Urinary tract repair, Collagen/vicryl.

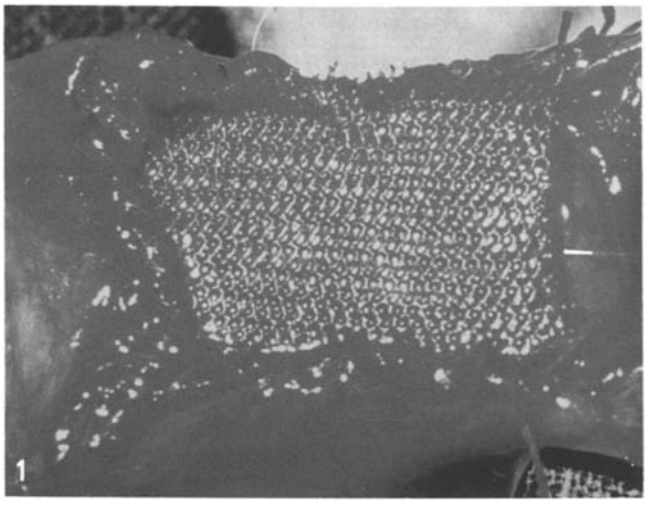

Fig. 1. Collagen/Vicryl composite membrane sutured into place over excised area of urinary bladder (x3.2)

Introduction

A collagen/vircryl composite membrane has been successfully used to close the defect of partial nephrectomy site in the rabbit [2]. It gave satisfactory haemostasis, prevented urine leakage, and was replaced by a pseudo-capsule in less than twenty weeks.

The present study describes the further use of this membrane to repair full thickness bladder defects.

Materials and Methods

Collagen/vicryl composite membrane was prepared as described previously [1]. Adult male New Zealand white rabbits weighing 2.8–3.2 kg were used for the experiments. As in previous experiments [2], the animals were given a one week course of Aureomycin on arrival at the laboratory. At least seven days were allowed to elapse before any animal was used for experimental purposes.

A general anaesthetic was administered and the animals monitored as previously [2]. A midline incision was made, and the bladder delivered into the wound. Two series of experiments (determined by the size of the patch) were performed. In both a small, full thickness, portion of the anterior wall of the bladder was excised and the resultant defect closed by suturing into place either a 3 x 3 cm or 1.5 x 1.5 cm patch of membrane using vicryl or chromic catgut sutures (Fig. 1). In fifteen of the animals with the smaller prosthesis, the operative site was identified by including non-absorbable nylon (Ethilon) marker sutures.

Thereafter, the animals were sacrificed at regular intervals over a six-month period (Tables 1 and 2).

A careful post-mortem examination was performed and the appropriate portion of bladder removed for subsequent histological examination.

Results

The results of the experiments are summarised in Tables 1 and 2. All nine rabbits in which a 3 x 3 cm membrane was used showed adhesions of bladder to abdominal wall and bowel at post-mortem. Four animals died from causes such as urine leakage, gross-infection and ureaemia (Table 1).

Table 1. Results of experiment using 3 x 3 cm size collagen/vicryl membrane

Sacrifice time	No. animals	Post-mortem and histology
1 Wk	2	Some urine leakage found in both animals. No growth of normal urothelium was observed
7 Wks	1	Satisfactory repair, although repair area was contracted
10 Wks	1	Repair area contracted. Urinary calculi found. Good epithelial covering. Prosthesis replcaed by scar tissue
12 Wks	1	Repair itself satisfactory but urinary calculi found with evidence of chronic infection
Animal died at 3 days		Damaged ureters, uraemic death with gross inflammation around repair
Animal died at 3 days		Urine leakage with infection. Histology showed no epithelium over repair site
Animal died at 4 days		Bowel necrosis. Iodoform used as disinfectant on this animal which may have caused necrosis
Animal died at 17 days		Gross infection. Degenerate epithelium. Holes found in prosthesis

Table 2. Results of experiment using 1.5 x 1.5 cm collagen/vicryl membrane

Sacrifice time	No. animals	Presence of infection	Presence of bladder calculi	Post-mortem and histological findings
2 Wks	2	2	–	Too early to assess effectiveness of repair
3 Wks	1[a]	1	–	
6 Wks	2[a]	1	1	Successful result good urothelial cover and repair
8 Wks	1	1	–	Poor urothelial growth but successful repair. Fat necrosis observed
10 Wks	2[a]	–	–	Both repairs successful. Excellent urothelial covers in one case. The other animal showed a good epithelial covering of the repair
12 Wks	2	1	–	Bladder repair good, but poor urothelium
14 Wks	2	2	–	Successful repair with good urothelium in both animals
15 Wks	2[a]	–	–	Both animals showed a successful repair with good urothelium
16 Wks	2	1	2	Successful and good urothelium growth. One animal had a very thin walled bladder
18 Wks	2	1	2	Good repairs and urothelium growth
20 Wks	2[a]	–	1	Good repairs. One poor urothelium
20 Wks	2	–	1	Results generally good. One poor urothelium
26 Wks	2	1	–	Two very good repairs to bladder with good urothelial growth

[a] No non-absrobable marker sutures used

Two animals were sacrificed at one week. Both had some urine leakage, and in one, bladder calculi were found. In neither animal could a normal urothelium be identified. The remaining three animals were sacrificed at 7, 10 and 12 weeks. Study of these animals revealed that on a microscopic examination there was a successful repair, the composite having been replaced by scar tissue which was lined with a normal looking urothelium. There was, however, visual evidence of contraction of the repair site. At 7 and 12 weeks, signs of chronic inflammation were shown histologically, and urinary calculi were observed at 10 and 12 weeks. In all animals where bladder concretions were observed, the calculi were found adhering to the non-absorbable sutures which appeared to have migrated into the lumen i.e. single "hanging bladder calculi".

In 24 rabbits in which the 1.5 x 1.5 cm patch was used, there was again evidence of adhesion of bladder to bowel and to the abdominal wall. The repair area was generally visible as whitish scar tissue, and the positions of the non-absorbable marker sutures (used in 14 cases) indicate a minimum of contraction of the operative site. Urine leakage was not observed in any of these experiments.

Evidence of local infection was found in 11 rabbits, and in six, bladder calculi were observed. In nine animals, non-absorbable sutures were not used, and bladder calculi were observed in only one case.

Post-mortem examination at 2 and 3 weeks showed that no epithelial re-growth had taken place, the collagen/vicryl composite membrane was still present, and gross infection was found in all three cases.

In the longer-term experiments, however, it was found that the collagen/vicryl composite was replaced by collagenous scar tissue and lined with a transitional epithelium (Fig. 2). Normal detrusor muscle could be seen on either side. In some animals, regeneration of smooth muscle was observed in the repair area following replacement of the prosthesis with collagenous scar tissue (Fig. 3). Thus, a satisfactory repair to the bladder defect of strong collagenous scar tissue lined by urothelium was found in 16 of the 24 animals used.

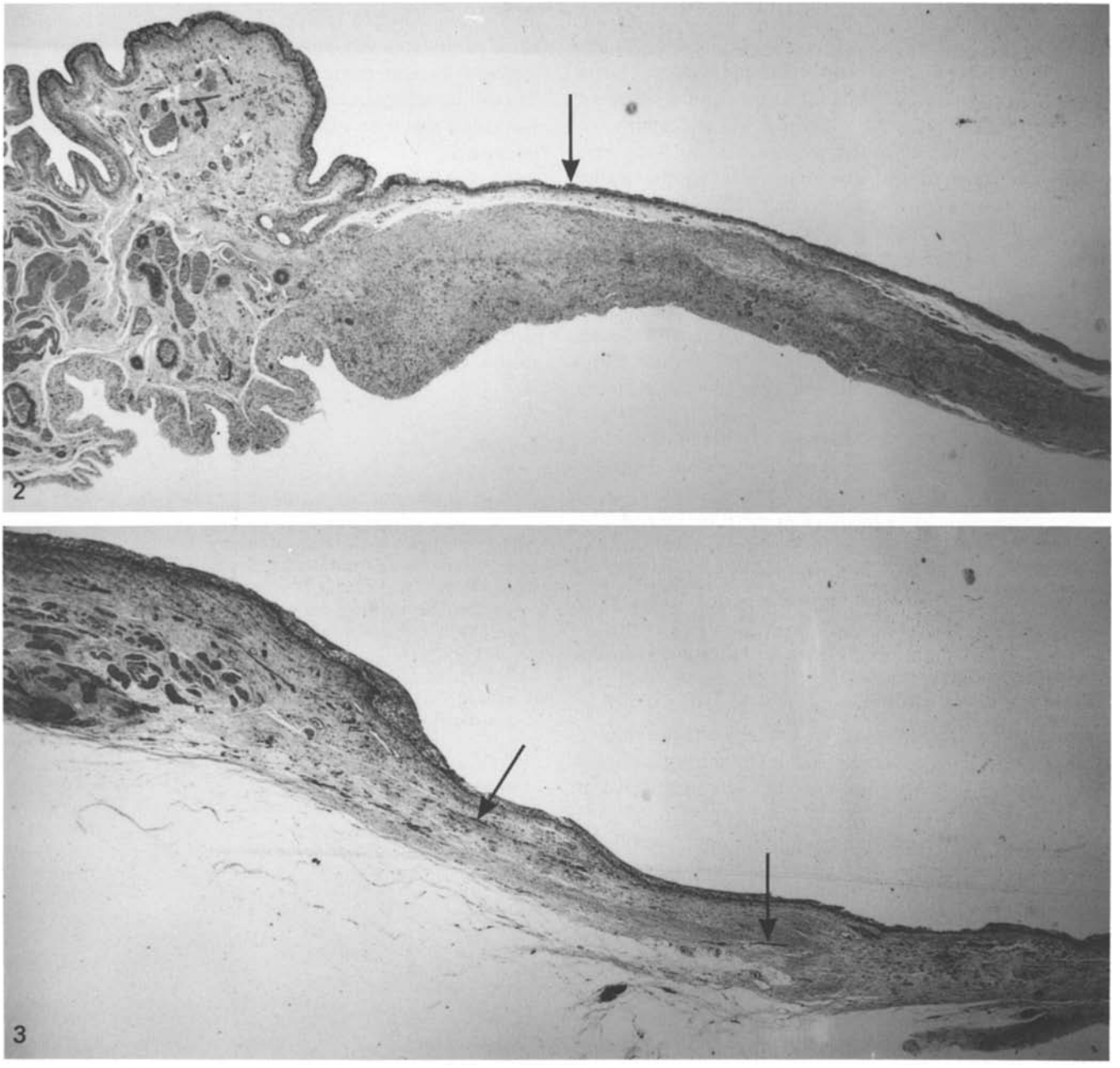

Fig. 2. Bladder at ten weeks showing collagen/vicryl composite membrane replaced by collagenous scar tissue lined with transitional epithelium, indicated by *arrow* (HPS trichrome stain, x23.3)

Fig. 3. Bladder at twenty weeks showing membrane replaced by tissue lined with transitional epithelium. Areas of smooth muscle regeneration indicated by *arrow* (HPS trichrome stain, x23.3)

Discussion

A piece of collagen-coated vicryl mesh has been used successfully to repair a defect following the excision of a full-thickness portion of tissue from the urinary bladder of experimental rabbits. The composite was eventually replaced by collagenous scar tissue lined with a transitional epithelium and, in those experiments where the smaller prosthesis was used, minimum shrinkage took place. Macroscopically, the operative site could be identified as whitish scar tissue, and a successful repair to the defect was observed as early as six weeks.

Problems encountered during the investigation consisted of a high incidence of infection and urinary calculi, both of which would be of concern to urologists hoping to use this material in patients. However, it must be borne in mind that no peri- or post-operative antibiotics were administered to the animals and that in all but one animal, bladder calculi occurred only where non-absorbable sutures had been used as markers. These had migrated into the

lumen of the bladder thus acting as a nidus for stone formation.

Those problems particularly associated with the larger (3 cm x 3 cm) prosthesis, such as leakage of urine, apparent shrinkage of the repair site, and a relatively high number of animal deaths, are clearly serious problems, but they were largely overcome in the second series using the smaller patch. It must be emphasised, however, that these animals were the first nine rabbits in which this type of repair was attempted and that experience was being gained in perfecting the operative technique at this early stage.

Of the 24 animals in which the smaller patch was used, the repair could be classed as highly successful in 16 cases. Of the remainder, three were too early to assess and in the others, the prosthesis had still been replaced by collagenous scar tissue.

Earlier workers [3] had used both absorbable and non-absorbable materials to cover experimental bladder defects in dogs and rabbits. The use of a non-absorbable material (tetron connective tissue membrane) was unsuccessful. The membrane was not integrated into the bladder wall, nor was it fully covered with an epithelial layer. Ulceration and necrosis of the operative site were also observed during the experiment.

Using an absorbable gelatin sponge, more successful results were obtained [3]. An early inflammatory infiltrate subsiding after 6 weeks was observed in the prosthesis which itself became replaced with connective tissue covered with an epithelium. At six weeks muscle regeneration was also observed. However, one third of the animals died of urine leakage in the early stages of the experiment.

We believe that the collagen/vicryl composite membrane has many advantages. It biodegrades readily and hence leaves no permanent foreign material which may require to be discharged by the bladder. It is strong enough to readily allow suturing, is leak-proof against urine and is eventually replcaed by scar tissue lined with a normal urothelium. Smooth muscle regneration in the repair area as early as six weeks has also been observed during the course of our experiments.

In conclusion we therefore feel that the collagen/vicryl composite membrane could well prove to be a material of value in augmenting the capacity of contracted bladders in the human, and thus avoid the use of bowel.

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