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Patch Grafting the Renal Pelvis and Ureteropelvic Junction*

A Comparative Study in Pigs Using Lyophilized Dura Mater and Free Peritoneum

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Summary. Lyophilized dura mater (Lyodura) and autogenous free peritoneum were compared in the replacement of the partially resected renal pelvis and ureteropelvic junction (UPJ) in the pig. The Lyodura and peritoneum grafts were both progressively resorbed, and replaced by fibroblasts which formed a mature scar lined by transitional epithelium, but without smooth muscle regeneration. Lyodura was found to be superior to free peritoneum with a longer time before resorption of the graft, less intense inflammatory reaction, absence of metaplastic bone formation, less risk of urine leak and greater ease of surgical manipulation.

Key words: Pyeloplasty – Lyodura – Peritoneum – Pigs

Introduction

Lyodura is made from human dura mater which has been processed to remove all soluble proteins including enzymes and antigens. The dura then undergoes lyophilization, during which it is frozen and then rapidly dehydrated in a vacuum, resulting in a felt-like structure composed of pure collagen, which is extremely strong. The Loydura currently available is soft and pliable, and does not require rehydration prior to surgical use. Lyodura has been used to replace tissue defects in numerous areas of surgery including neurosurgery [14] and maxillo-facial surgery [6]. Its use in urology has previously been restricted to augmentation of the bladder [5], patch grafting the bulbar urethra [15] and as a urethral sling for stress incontinence in women [19]. Defects of the renal pelvis or stenosis of the UPJ, which are not amenable to primary plastic reconstruction due to deficient local tissue, may be repaired with a primary patch graft or with an intubated ureterotomy. Lyodura has not previously been used to graft the renal pelvis or repair the UPJ, hence we studied the feasibility of using Lyodura as an alternative to the currently accepted free peritoneal graft.

Materials and Methods

Four male and two female pigs weighing 20–38 kg were anesthetized with Ketamine Hydrochloride 12 mg/kg and Atropine Sulphate 400 mcg. by intramuscular injection. Anesthesia was continued with Thiopental Sodium 25 mg/kg intravenously and Fluothane 1.5% with oxygen at 6 l/min via an endotracheal tube. A Cephalosporin antibiotic was given following induction of anesthesia, and repeated on the first postoperative day. The kidney was exposed in the extraperitoneal space through a flank incision. Using the 12 available kidneys in 6 pigs, the generous extrarenal pelvis was partially excised leaving a defect in the posterior wall of approximately 3 x 2 cm, which accounted for at least 50% of the renal pelvis. In 2 kidneys the UPJ was included in the excision. In 6 of the kidneys the defect was replaced with a patch of Lyodura, while in the remaining 6 kidneys a free patch of autogenous peritoneum was used to repair the defect. The peritoneum was obtained from the adjacent anterior peritoneal envelope. All 12 patch grafts were sutured into the renal pelvic defects with continuous 5/0 chromic catgut, and were closely inspected to ensure a watertight closure. The peritoneal grafts were sutured with the serosal surface directed toward the lumen. Ureteric stents or nephrostomy tube drainage were not used, however an extraperitoneal drain was inserted for 24–48 h postoperatively. In the case of each peritoneal patch, the peritoneal donor site was repaired with a continuous 2/0 chromic catgut suture.

In each pig the right renal pelvis was patch grafted at the first operation, and thereafter a right nephroureterectomy was performed after a predetermined time interval. During the second operation the now solitary left kidney was patch grafted, and after a further predetermined time interval, the animal was sacrificed and a left nephroureterectomy performed. Intravenous pyelography, urine culture and serum creatinine were obtained in each animal prior to all procedures. All animals survived to the end point of the experimental protocol, which resulted in 12 renal pelvic grafts for assessment. The 6 Lyodura grafted kidneys were removed at 1, 3, (2 grafts), 4, 6 and 12 weeks; while the peritoneal grafted kidneys were removed at 1 (2 grafts), 2, 4, 6 and 15 weeks following grafting. The UPJ had been included in the excision of the kidneys examined at 12 weeks (Lyodura), and 15 weeks (peritoneum).

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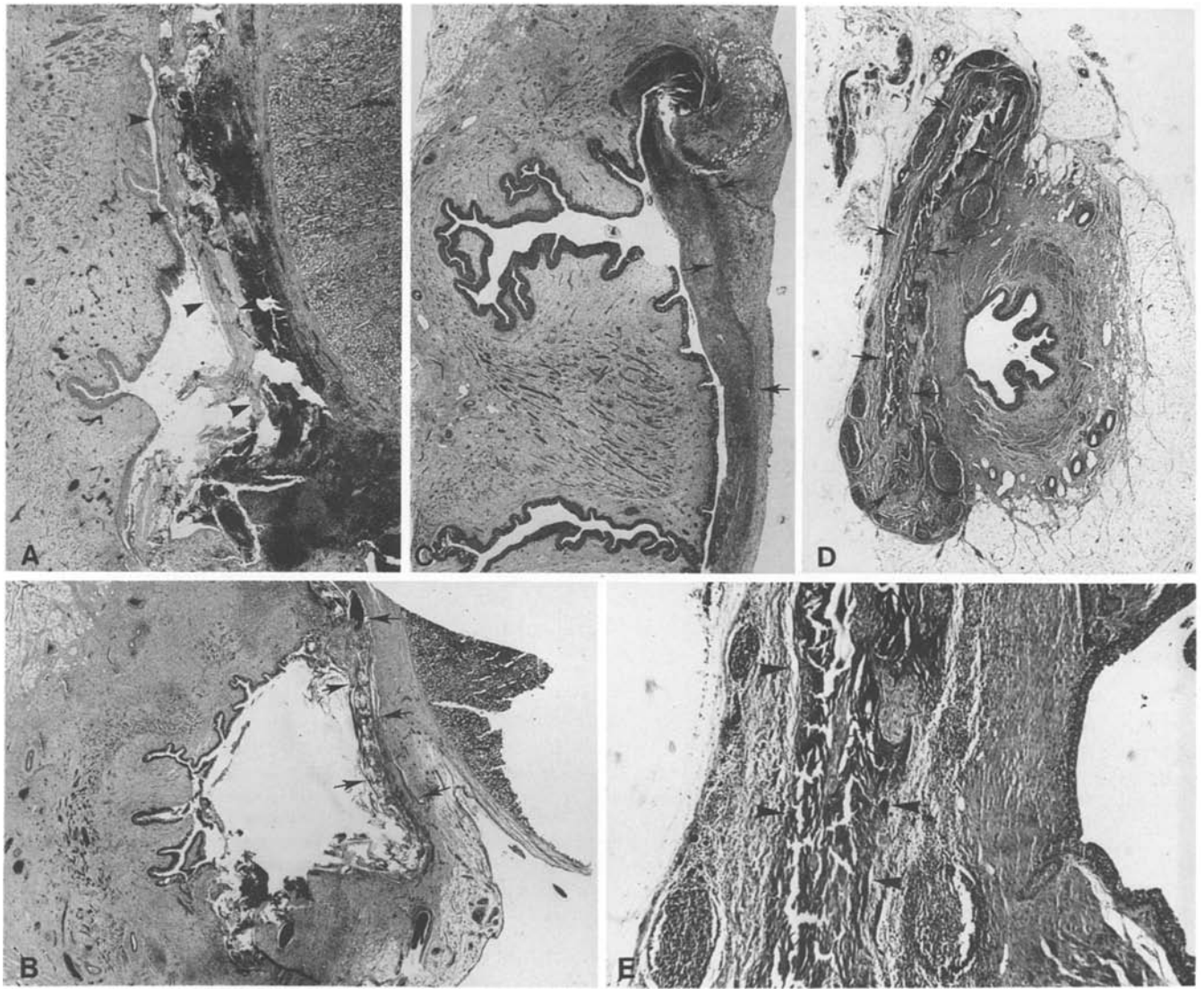

Fig. 1. A Lyodura graft remains intact at 1 week. H & E, reduced from x5.5. **B** Lyodura graft fragmented with ingrowth of fibroblasts. **C** Lyodura progressively resorbed and replaced by scar tissue at 6 weeks. **D** Lyodura graft at 12 weeks. Regeneration of transitional epithelium, but absence of smooth muscle at graft site. H & E, reduced from x5.5. **E** Lyodura graft at 12 weeks. Graft displaced from luminal surface by ingrowth of fibroblasts. H & E, reduced from x24

Results

The experimental results indicate that the Lyodura and free peritoneal grafts heal by similar processes.

Lyodura

In all 6 kidneys the Lyodura graft was found to be well incorporated into the renal pelvis, however a fragment of Lyodura was found extruded into the lumen of the kidney examined at 4 weeks post grafting. Lyodura is birefringent under polarized light, and this enabled the graft material to be positively identified on histological section. The Lyodura graft remained intact for the first week, forming a seal over the pelvic defect (Fig. 1A). Initially there was no foreign body reaction directed at the Lyodura, however during the third and fourth weeks the Lyodura gradually became fragmented and surrounded by chronic inflammatory cells with an ingrowth of fibroblasts between the strands of graft material (Fig. 1B). At 6 weeks scar tissue had almost completely replaced the Lyodura, and granulation tissue now formed the seal over the renal pelvic defect. Transitional epithelium had incompletely regenerated by 6 weeks, but there was no evidence of smooth muscle regeneration (Fig. 1C). At 12 weeks the Lyodura had been completely displaced from the luminal surface and was infiltrated by fibroblasts and histiocytes. The transitional epithelium was completely regenerated and the lumen of the renal pelvis appeared to be of near normal configuration (Fig. 1D, E). Calcification was not seen at the graft site, either in the form of luminal encrustations or as intramural bone formation.

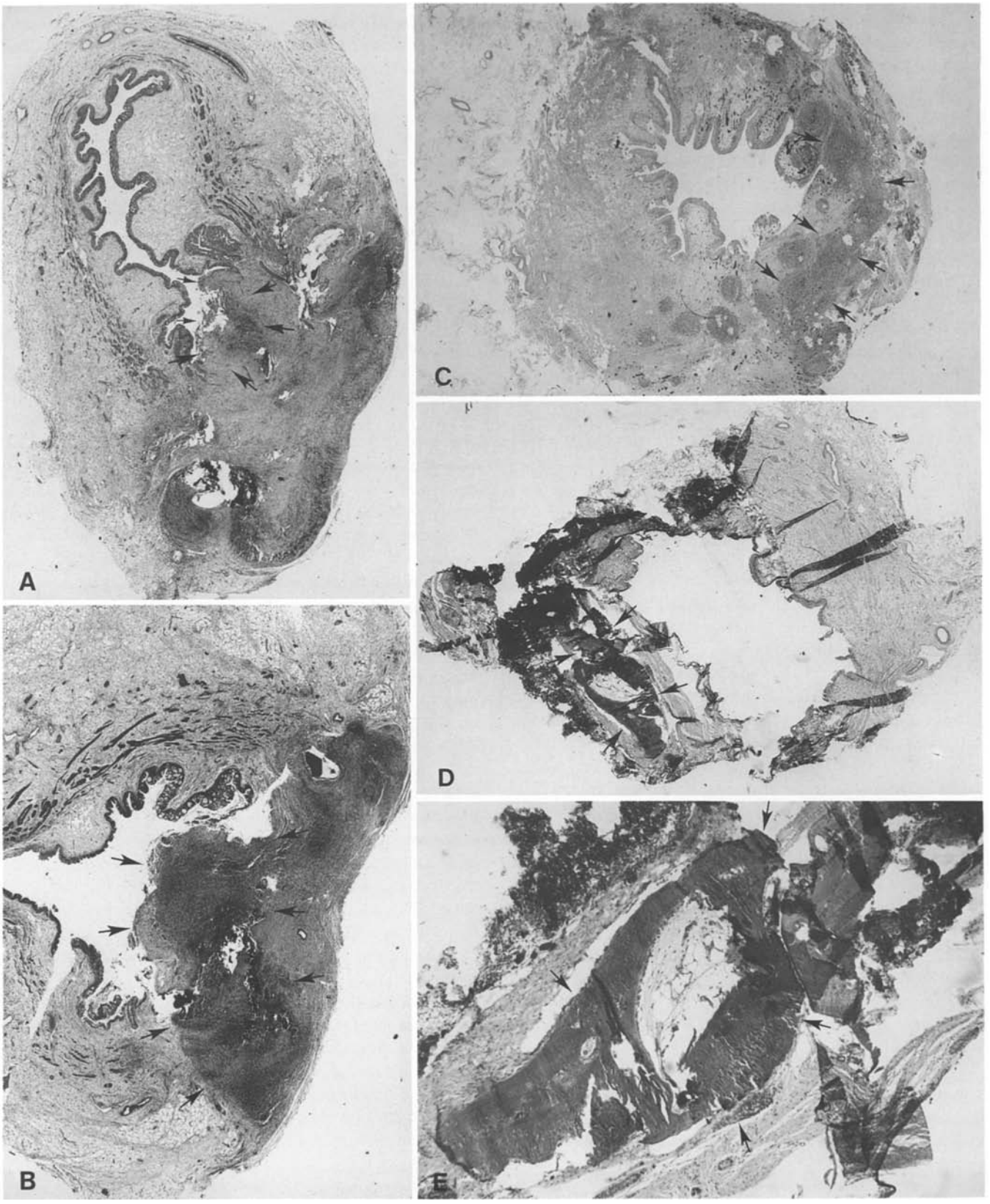

Fig. 2. A Peritoneal graft at 1 week. Necrosis of graft with chronic inflammatory infiltrate. H & E, reduced from ×6. **B** Peritoneal graft at 2 weeks. Graft necrosis with intense inflammatory response. **C** Peritoneal graft at 6 weeks. Reepitheliasation completed. Graft replaced by scar tissue. **D** Peritoneal graft at 15 weeks. Metaplastic bone formation at graft site. H & E, reduced from ×5.5. **E** Magnification of peritoneal graft at 15 weeks. Bone formation evident, surrounded by scar tissue. H & E, reduced from ×22

The kidney appeared normal in all sections examined. The IVP appearance was variable, with Grade 1 hydronephrosis present at 1 and at 12 weeks post grafting, but no hydronephrosis at 3, 4, and 6 weeks. There was no radiological evidence of urinary extravasation in any of the Lyodura grafts. *E. coli* infection was associated with one graft removed at 3 weks. A further graft was examined at 3 weeks, in the absence of infection, and the results compared. The presence of infection in the urine did not alter the healing of the Lyodura graft.

With the solitary kidney examined at 12 weeks, the serum creatinine had risen from 1.2 mg% to 1.8 mg%, however all other creatinine levels remained stable.

Peritoneum

Two of the 6 free peritoneal grafts developed large retroperitoneal extravasation of urine due to graft necrosis and rupture. The remaining 4 grafts appeared to be well incorporated into the renal pelvis.

The free peritoneal graft remained intact at 1 week but subsequently underwent necrosis and was rapidly replaced by fibroblasts and a chronic inflammatory infiltrate (Fig. 2A‘ B). Reepithelialization was complete at 6 weeks (Fig. 2C), and at 15 weeks the graft was completely replaced by scar tissue and a regenerated transitional epithelium. Metaplastic bone formation was present at the free peritoneal graft site at 15 weeks (Fig. 2D, E). The kidney was histologically normal in all cases where the graft remained intact, while a polymorphonuclear leukocytic submucosal infiltrate was present in the 2 grafts with leakage and infection. IVP studies revealed extravasation of urine with 2 grafts; grade 1–2 hydronephrosis was noted in the first 2 weeks, with normal appearance on IVP at 6 and 15 weeks.

In the solitary kidneys examined at 6 and 15 weeks, the creatinine was elevated from 0.9 to 2.1 mg%, and from 1.5 to 2.4 mg% respectively. All other creatinine values remained stable.

Both instances of peritoneal graft leakage were associated with urinary infection. The pathogens were *Salmonella cholerae suis* and *S. aureus.*

Discussion

The need for reconstructive surgery to the renal pelvis or UPJ may arise in several circumstances. Renal pelvic defects may result from open surgery related to removal of staghorn calculi, or calculi within an intrarenal pelvis.

Percutaneous nephrolithotomy may also result in damage to the renal pelvis or UPJ. Partial resection of the pelvis may be required for excision of a localised transitonal cell carcinoma. A failed pyeloplasty may require a patch graft to repair a recurrent UPJ obstruction, especially if local tissues are fibrosed or inadequate for flap repair. If the defect includes the UPJ, and a primary repair is not possible, then a Davis intubated ureterotomy has traditionally been used [11]. In order to avoid the risks of urine extravasation with resulting secondary scarring and stenosis inherent with the Davis technique, attempts have been made to find a suitable method of primary repair of the defect. The previously reported methods for primary closure of a renal pelvic defect include a free peritoneal patch or a pedicled renal capsular flap. The renal capsular flap has been used with good results both in animal experiments and clinically [2, 3]. However, if the renal capsule is likely to be scarred and adherent due to previous surgery or infection, then a renal capsular flap is contraindicated [3]. The free peritoneal patch has been reported as a satisfactory method of replacing renal pelvic tissue [12, 13], as well as a form of cystoplasty [4]. In a series of 30 patients [12], the renal pelvis was reconstructed with a free peritoneal graft, but was complicated by extravasation of urine or obstruction in 4 of 30 patients. In 8 of the patients an omental graft was used as well, indicating the anticipated need for additional reinforcement of the peritoneal graft. Free peritoneal grafts also have the disadvantages of opening the peritoneal cavity with the risk of damage to abdominal viscera, bowel adhesion formation, intestinal herniation and peritonitis, especially if extravasation of urine should occur.

Lyodura has been used to augment the urinary bladder experimentally [1], and for contracted bladder or following subtotal cystectomy for carcinoma [8]. Lyodura has also been used successfully to replace a segment of ureter in the rabbit [7]. These results stimulated our use of Lyodura in an attempt to find a better method of patch grafting the renal pelvis and UPJ.

In our experience we found the free peritoneal graft difficult to handle due to its fragility and ease with which sutures could tear through the graft tissue. It was not easy to obtain a watertight sutureline, and in our study, 2 of 6 peritoneal grafts were complicated by extravasation of urine and sepsis. Lyodura formed a better watertight seal than peritoneum, with no evidence of extravasation or perirenal inflammation in the 6 grafts examined. Lyodura was found to be easier to manipulate than peritoneum, and it could be cut to precisely the size required to fill the defect without the need to interrupt normal tissue.

In addition, the Lyodura functioned as a stronger support for suture placement. In our study, metaplastic bone formation did not occur with Lyodura, as has been previously reported with this use in the bladder [1]. On the other hand, we did find bone formation in the free peritoneal graft examined at 15 weeks. The single instance of extrusion of a fragment of Lyodura into the lumen of the pelvis cannot be easily explained, especially as the histological section of the graft demonstrated almost complete incorporation of the graft by fibroblasts in the wall of the pelvis. A possible explanation may be that the Lyodura had undergone buckling due to wound contracture, and a fragment sheared off from the graft. The Lyodura and free peritoneal grafts both functioned as a temporary luminal seal for the renal pelvic/UPJ defect, however the Lyodura was resorbed

slowly, with graft material persisting longer than with peritoneum. A comparison of the histological pattern of healing indicated that both grafts act as a matrix for the ingrowth of fibroblasts followed by the regeneration of transitional epithelium. Smooth muscle regeneration was not seen in either graft. Previous experiments indicate that smooth muscle will only regenerate following excision of a segment of the ureteral wall, if the wound edges are not distracted by a "rigid bed about the healing ureter" [10]. In Hinman's experiments smooth muscle regenerated from contraction of the fibrous tissue drawing preexisting muscle around the lumen. Contraction further stimulated new smooth muscle formation. Lyodura and peritoneum may both act as a rigid bed around the renal pelvis, thus accounting for the lack of smooth muscle in the repaired wall.

We conclude that, in this limited series, Lyodura is a suitable alternative to free peritoneum, for the repair of defects in the renal pelvis or ureteropelvic junction. Further studies on larger numbers and more extended periods of followup have been undertaken, at our institution, to confirm these early encouraging results.

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