Urological Research 5, 127-132 (1977)

Urological Research

Evaluation of Different Types of Emboli in Transcatheter Embolization of Rat Kidney

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Received: May 12, 1977

Summary. The properties and characteristics of a variety of embolic materials (Clots - surgicel - gelfoam - barium - cyanoacrylates) were investigated by transcatheter embolization of the rat kidney. Clots and surgicel result in temporary embolization, with return of normal renal function. Gelfoam barium and cyanoacrylates produce definitive embolization. Only barium was found in veins.

Key words: Rat kidney - Transcatheter embolization - Embolic materials - Experimental surgery - Radiology.

Transcatheter embolization has become more widely used in the management of renal tumours, trauma and arteriovenous fistulae (1, 2, 4, 7, 10, 14, 16). The aim is to produce ischaemia in a given area by temporary or definitive occlusion of the supplying vessels. The embolic materials that can be used are various and heterogeneous and include clots, fat, muscle, pellets, Gelfoam and several others. While some of these have already found a broad clinical application (1, 6, 7, 10, 13, 17), the majority of them have been rarely employed and their characteristics are not yet well known. In this study we tested the properties and characteristics of various embolic materials in an experimental model, using transcatheter embolization of the rat kidney. It was achieved by transiliac selective catheterization of the renal artery (5).

MATERIALS AND METHODS

A total of 80 Wistar male rats weighing 250-300 g were used. The surviving animals (63) were divided in to the following groups:

Group 1: (n = 3) left renal artery was ligated surgically near its origin.

Group 2: (n = 5) simple catheterisation of the left renal artery was performed.

Group 3: (n = 10) left kidney embolized with 0.1 ml of autologous clots (5) or autologous amino-caproic acid modified clots (5).

Group 4: (n = 10) left kidney embolized with Gelfoam, previously shredded with an electric whisk and suspended in 0.1-0.2 ml saline.

Group 5: (n = 10) kidney embolized with 0.1 ml of $BaSO_4$.

Group 6: (n = 5) embolised with very small fragments of acetate-cellulose gauze (Surgicel) suspended in 0.2 ml saline.

Group 7 (n = 10) and Group 8 (n = 10): injection into the renal artery of 0.2 ml of fluid acrylic resins: isobutyl-2-cyanoacrylate (IBC - Bucrylate Ethicon) and N-butyl-2-cyanoacrylate (NBC - Histoacryl, Braun) respectively.

The rats of the Group 3 were examined after 24 hours in order to assess the degree of clot lysis produced by spontaneous fibrinolysis. Three animals from this group were subjected to controlateral nephrectomy at the some time as embolization. The remaining animals were sacrificed on 3rd, 7th or 21st day after embolization; all the kidneys were examined histologically.

TECHNIQUE

The animals were given fluids only from the evening before operation. Anaesthesia was

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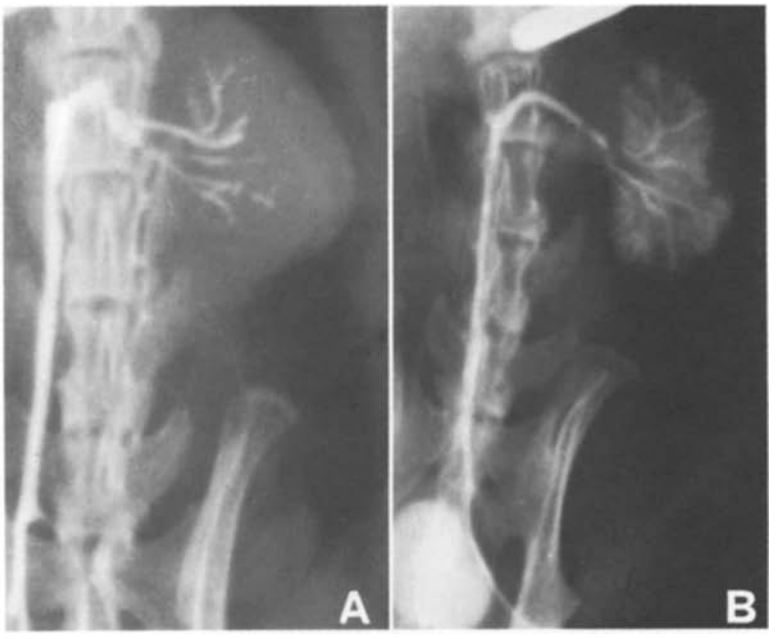

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Fig. 1. Selective renal catheterisation

Fig. 2. A: selective arteriography immediately after embolization with autologous clots. B: the same kidney after 3 days. Almost complete revascularization of the kidney has occurred. A small wedge shaped cortical infarct persists

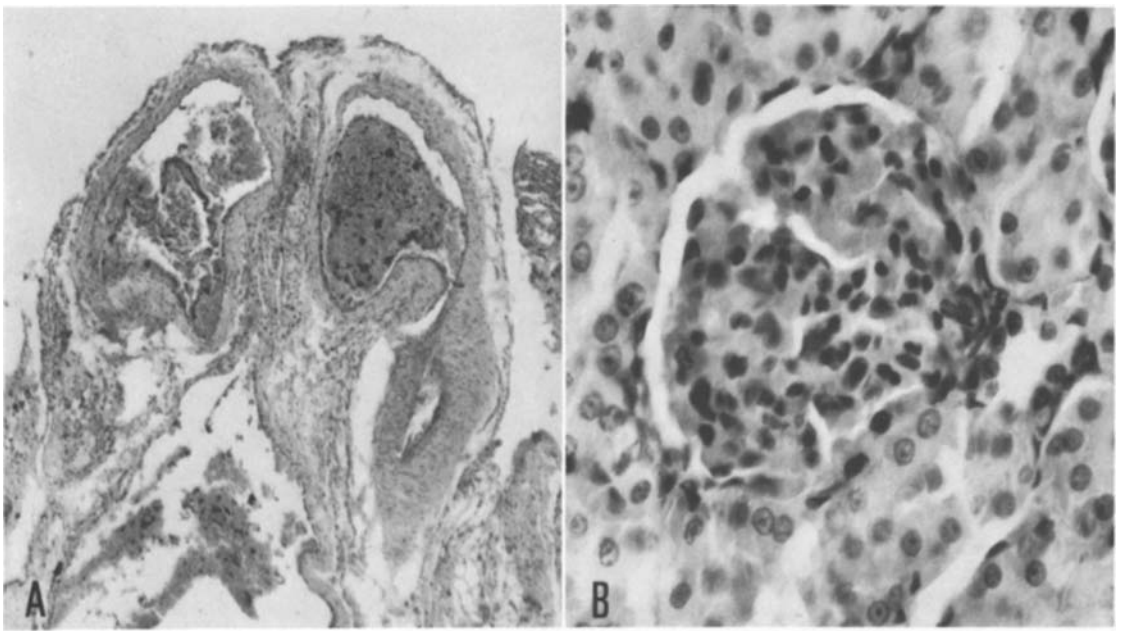

Fig. 3. A: arterial vessels filled with clot. B: large numbers of red blood cells within a glomerulus

induced in most cases by ether with an open mask; in other cases Leptofen (a mixture of Deidrobenzoperidole and Phentanyle) i. m. was used. The abdomen was opened by a midline incision and the left renal artery near the aorta was dissected (in 5 animals the right renal artery was used). The left renal artery was then separated from the vein, leaving the suprarenal vein intact. A small polyethylene tube (o. d. 0.6 mm) was introduced through a short arteriotomy into the left iliac artery, which was distally ligated. The catheter was advanced to the level of the renal arteries. Selective renal catheterization was achieved by manually occluding the aorta and drawing the left renal artery upward (Fig. 1). Embolization was performed by injection of one of the above mentioned embolic materials; and considered

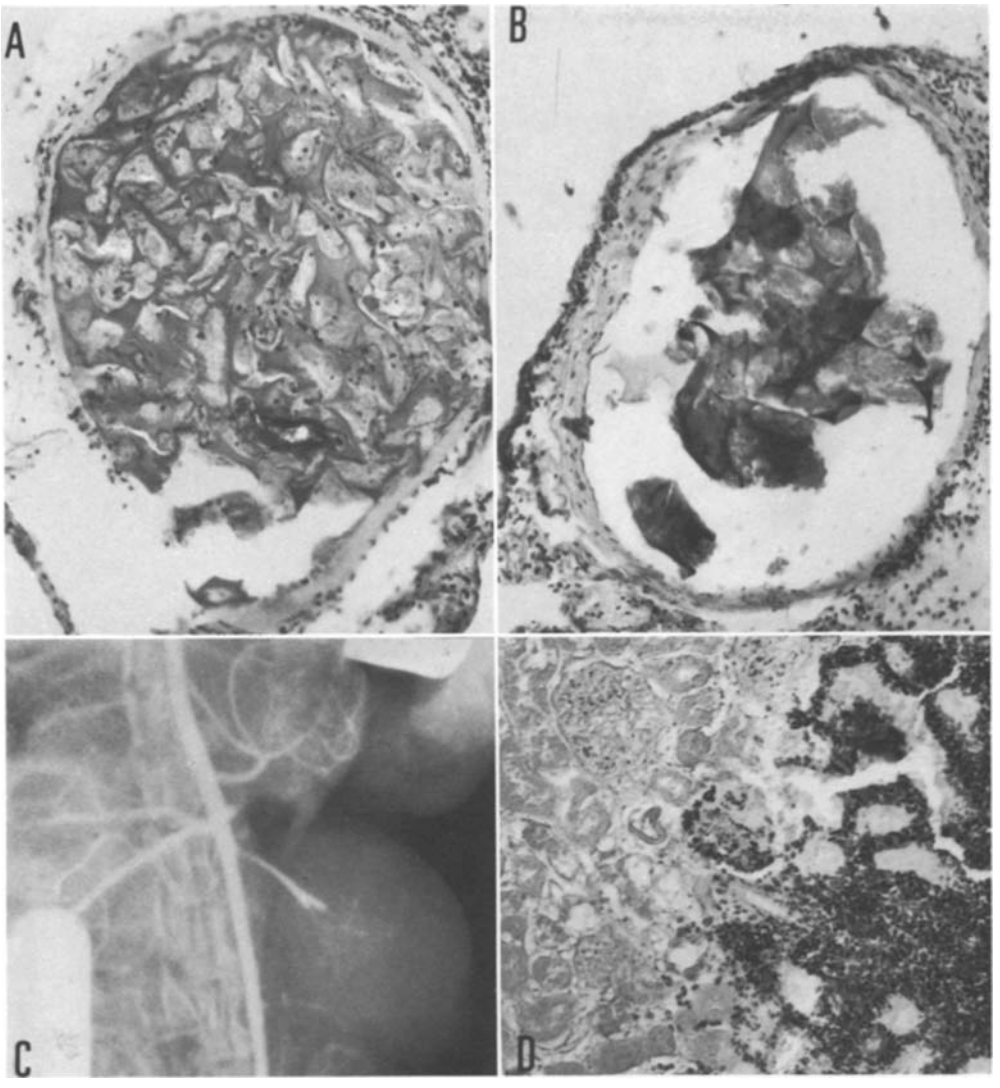

Fig. 4. A: gelfoam in the lumen of the renal artery 3 days after embolization. B: idem after 21 days. C: angiogram 21 days after embolization with gelfoam. D: after 21 days the kidney is completely destroyed and there is dense cellular infiltration

to have been achieved when the kidney appeared fully ischaemic and the distal arterial branches were pulseless. Depending on the type and the quantity of embolus, the trunk of the renal artery may or may not pulsate. The contralateral kidney was always kept under observation in order to assess its vitality and to exclude the possibility of over spill of emboli. The catheter was then removed and the iliac artery ligated. In all cases good perfusion of the legs was observed.

This technique of selective catheterization differs from that described originally by Ekelund and Olin in 1970 (5) who used a transfemoral approach and made the selective catheterization under fluoroscopy, employing a purpose built image intensifier.

RESULTS

No post-operative deaths were observed in groups 1 and 2. The mortality was 21% (17 cases) in the embolized rats and was caused mainly by technical problems associated with the use of the acrylic resins. Peritonitis was another important cause of death. In one case renal failure followed left renal embolization with autologous clots and right nephrectomy.

Group 1 (surgical ligation of the renal artery). Total necrosis of the kidney was observed.

Group 2 (sham catheterisation). Normal kidneys confirmed by histological examination.

Group 3 (clots). In all but one animal complete lysis of the thrombus was observed within 24 h, both in simple and in modified clot

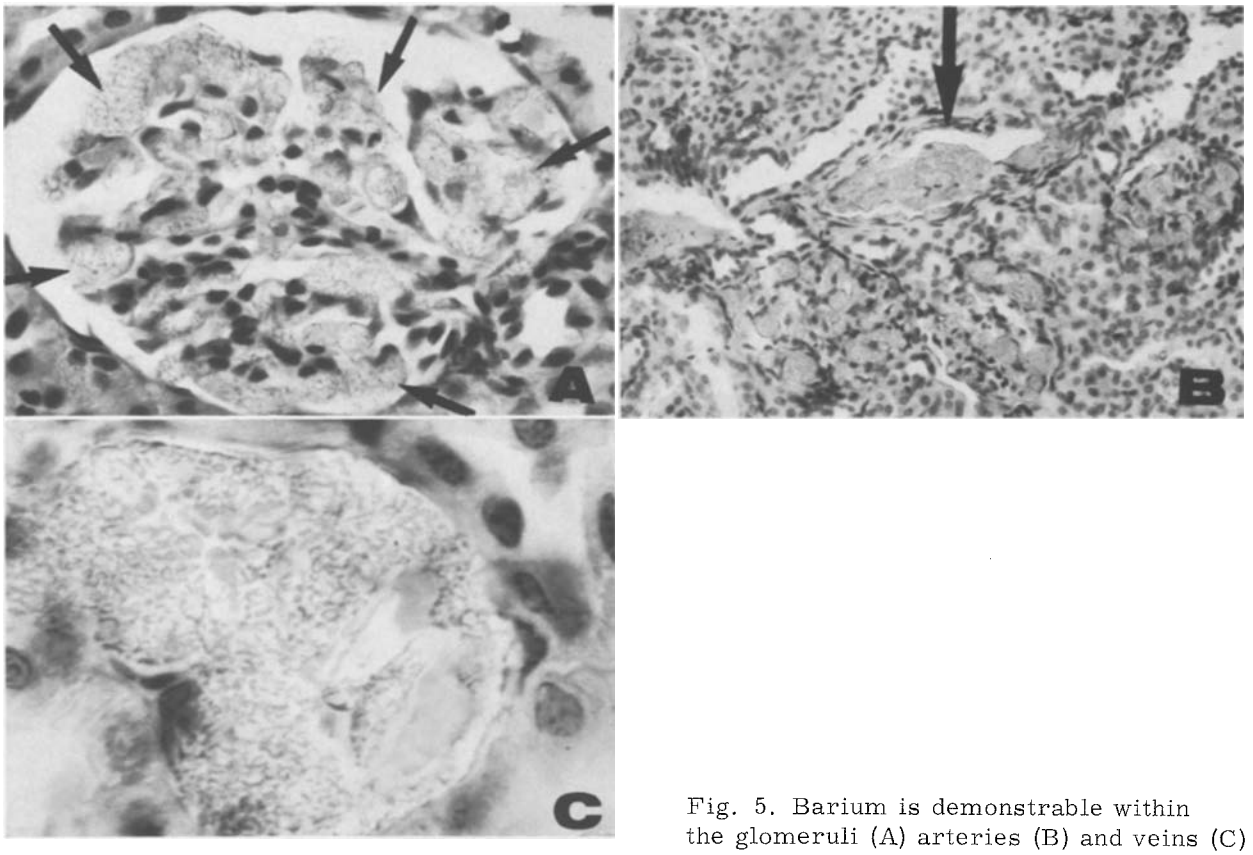

Fig. 5. Barium is demonstrable within the glomeruli (A) arteries (B) and veins (C)

embolization (Fig. 2). In one case, probably owing to an excessive clots injection (0.3 ml), contralateral nephrectomy led to renal failure and death; the embolized kidney appeared severely ischaemic and on histological examination the arteries appeared thoroughly filled with red blood cells, which were also present in a large quantities within the glomeruli (Fig. 3).

Group 4 (Gelfoam). In every case the kidney appeared macroscopically embolized even after 21 days. Microscopically the renal parenchyma was entirely destroyed, with remarkable cellular infiltration and perirenal fibrosis (Fig. 4). The arteries were obstructed by well organized thrombi, in which Gelfoam was easily identified (Fig. 4 A); after 21 days Gelfoam was partly reabsorbed (Fig. 4 B), but no recanalization was noted.

Group 5 (Barium). Barium was present in the main vessels and in all glomeruli (Fig. 5). It is very important to point out that it was found also in some venules (Fig. 5 C), demonstrating that Barium can pass the capillary filter. Its efficacy in embolization was very high; no revascularization was observed after 21 days.

Group 6 (Surgical). Almost complete revascularization of the embolized kidney was noted on the 3rd day.

Groups 7 and 8 (IBC and NBC). The renal artery was occluded from its trunk to the glomeruli by an hard thrombus of acrylic material (Fig. 6). The venules remained free. In the animals sacrificed after 21 days the kidney was completely destroyed and surrounded by sclerotic tissue. The arterial wall did not show any particular change. No difference was noted between the properties and characteristics of IBC and NBC.

DISCUSSION

A critical assessment of various embolic materials must take into account several points:

1) ease and availability of use
2) type, quality and duration of embolization
3) degree of toxicity and side effects.

The materials most difficult to handle are the acrylic resins, owing to their instant polymerization on contact with blood. If early polymerization leads to occlusion of the catheter, minimal spill-over into the aorta may result in irreversible damage. During clinical application of these substances we adopt a coaxial system which allows angiographic control (8). Embolization was in every

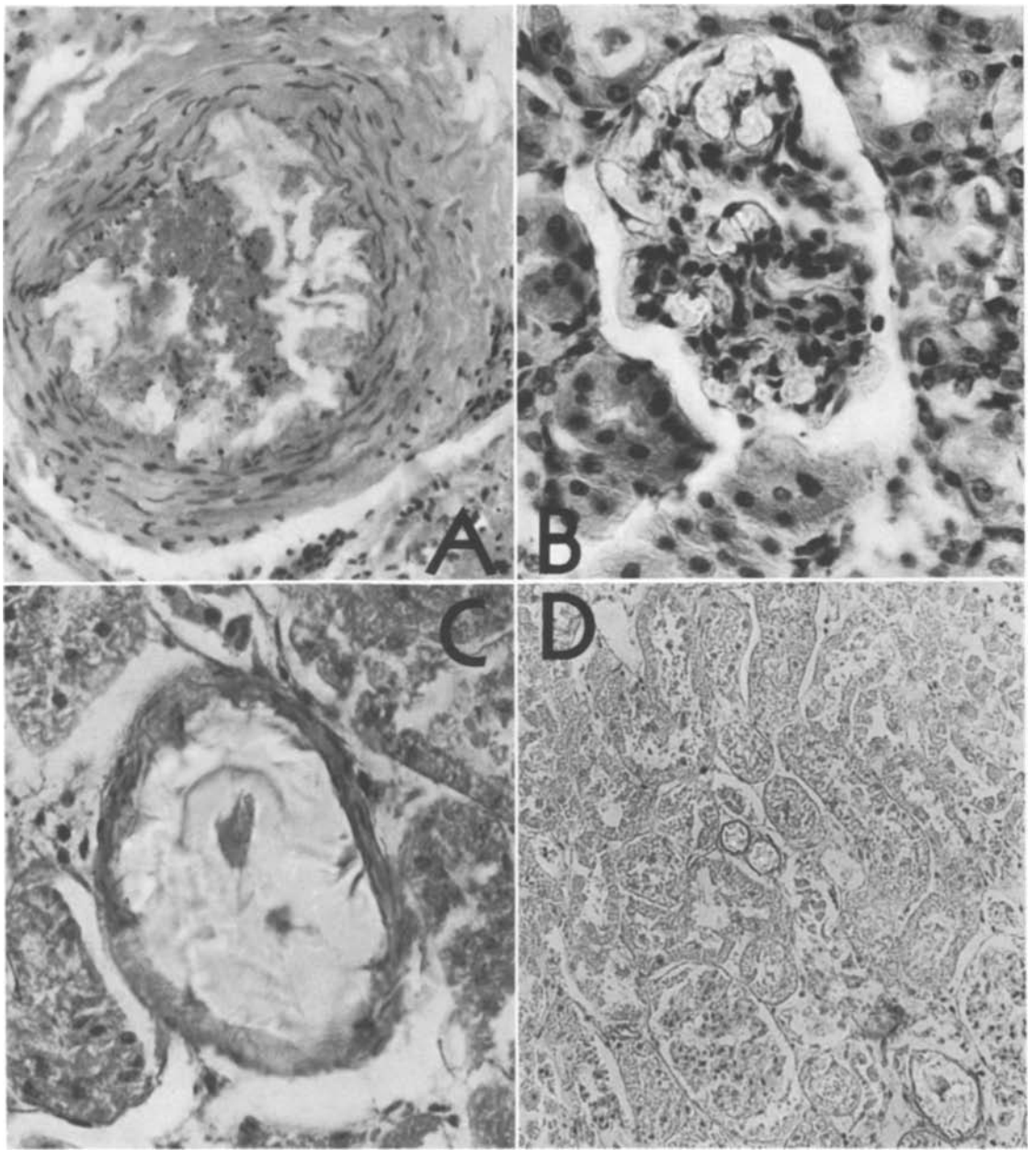

Fig. 6. Cyanoacrylate in the arterial lumen (A) and a glomerulus (B) after 7 days. Arterial lumen (C) and glomerulus (D) after 21 days. The renal parenchyma appears completely destroyed

case a distal one, with emboli reaching the glomeruli, no matter what type of embolic material had been used. Only Barium passed into the venous system. It is our opinion that although Barium is already in clinical use (9) it requires particular caution on account of the danger of pulmonary embolism. Neither of the two acrylic compounds used proved able to pass the capillary filter, unlike Luessenhops findings with methylmethacrylate (12).

Concerning the duration of embolization and its reversibility, our results are interesting. Embolization with autologous clots appears to be temporary and fully reversible. The infarcted areas in clot embolization were negligible and maintenance of renal homeostasis continued even in the absence of the other kidney. This is important in clinical application, because clots embolization has been used in cases of serious renal injury, in order to control the bleeding (3, 11, 15). Although this experimental finding may not be altogether valid in man, it is interesting that an excessive amount of clots cannot be dissolved to such a degree or quickly enough to preserve the renal function.

Surgical is quickly reabsorbed, with restoration of arterial patency and renal function

and might prove to be a suitable material for temporary embolization in man. In contrast, Gelfoam, never showed recanalization. It is easily available and cheap and its use is indicated in cases requiring persistent embolization such as in the preoperative and therapeutic embolization of renal cell carcinomas.

The acrylic resins, if correctly used, constitute a very efficient material for preoperative or definitive embolization. They ensure a "surgical" occlusion of the renal arterial tree, from the origin of the renal artery down to the glomeruli, provided that the arterial flow is maintained during injection.

No material showed a significant incidence of side effects and no evident chemical injury of the arterial wall was seen.

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