Transcatheter embolisation of renal arteries: a novel technique

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Between 1989 and 2004 we carried out embolisation of the renal artery in 72 patients with renal cell carcinoma, these being 44 embolisations immediately prior to nephrectomy and 28 palliative embolisations. Transcatheter embolisation of the renal artery in our own modification relies on the introduction of large, 70 mm x 1 mm x 1 mm corks of spongostan with silver clips attached for marking purposes. In palliative embolisation we supplemented this with threads of dexon and a pulp of sponge-dexon. Embolisation of the renal artery was done in 19 patients in disease stage T1, 16 in T2, 15 in T3, and 22 in T4. The patients were between 20 and 80 years old. In 8 patients we did palliative embolisation using a Gianturco coil. Preoperative embolisation was performed in order to simplify the process of removal of the kidney, shorten the time of operation, reduce bleeding, avoid the necessity of blood transfusion, and block the dissemination of cancer and embolic material. Palliative embolisation reduced or stopped haematuria and decreased pain, which prolongs the lives of patients. Introducing our own method of embolisation of the renal artery allows one to shorten the time of the procedure, as well as prevent the complications of embolisation.
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Key words:
- embolisation of the renal arteries
- renal cell carcinoma - CT examination
- palliative embolisation
- preoperative embolisation
- transcatheter embolisation
- spongostan-dexon pulp

Embolizacja tętnic nerkowych w modyfikacji własnej

W latach 1989-2004 przeprowadziliśmy w naszym ośrodku embolizację tętnic nerkowych u 72 pacjentów z rakiem nerki; wśród nich wykonano 44 embolizacje przed zabiegiem operacyjnym i 28 embolizacji paliatywnych. Modyfikacja embolizacji w naszym ośrodku polega na wprowadzeniu przez kateter dużych korków spongostanowych, o wymiarach 70 mm x 1 mm x 1 mm, znakowanych klipsem srebrnym, co pozwala śledzić umiejscowienie korka spongostanowego w odpowiedniej gałęzi tętnicy nerkowej. W embolizacji paliatywnej uzupełniano wypełnienie łożyska naczyniowego nerki przez podanie papki spongostanowo-deksonowej. Embolizacja tętnic nerkowych przeprowadzona została u 19 pacjentów w stadium T1, 16 w stadium T2, 15 w stadium T3 i 22 w stadium T4 choroby. Wiek pacjentów wahał się pomiędzy 20 i 80 lat. U 8 pacjentów wykonaliśmy embolizację paliatywną z zastosowaniem spirali Gianturco. Embolizacja przed zabiegiem operacyjnym wykonywana była w celu ułatwienia zabiegu usunięcia nerki, skrócenia czasu operacji, zmniejszenia krwawienia, unikniecia konieczności przetoczenia krwi i zapobieżenia rozsiewowi komórek nowotworowych. Embolizacja paliatywna miała na celu zmniejszenie lub zatrzymanie krwawienia, zniesienie bólu i przedłużenie czasu przeżycia pacjenta. Wdrożenie naszej metody embolizacji tętnic nerkowych pozwoliło na skrócenie czasu zabiegu operacyjnego i uniknięcie powikłań po embolizacji.
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Słowa kluczowe:
- embolizacja tętnic nerkowych
- rak jasnokomórkowy nerki - tomografia komputerowa
- embolizacja paliatywna
- przedoperacyjna embolizacja
- przezcewnikowa embolizacja
- papka spongostanowo-deksonowa

Introduction

In this article we present a novel embolisation technique of the renal artery. This method relies on the introduction of large corks of spongostan, with the dimensions 70 mm x 1 mm x 1 mm, marked with the silver clips, to the renal artery and supplementing the embolisation with threads of dexon or with sponge-dexon pulp.

This novel technique of embolisation of the renal artery was employed in the Department of Radiology of our hospital. Nephrectomy followed the embolisation in 44 cases; for 28 cases it was a palliative intervention.

Material and methods

We present the results of our research in 72 patients, 20 and 80 years old (average 59 years) treated from 1989-2004 due to the presence of tumour in the kidney. All were patients of the Urological Department of our hospital.

The embolisation material consisted of corks cut out of plates of spongostan. They were 70 mm x 1 mm x 1 mm in size and marked on the end with metal clips made of sterile, attenuated silver wire - test 800, practical for clipping aneurysms of the brain arteries in the past. The clips were pressed onto the spongostan corks in the operating room immediately before their introduction into the arteries. To introduce the embolisation material to the artery, a device constructed from an 8-cm-long catheter of our own design, furnished with a clasp and mini-tap, was used. Besides this, 20 ml and 5

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ml syringes, dexon threads in a ball and in pieces, vascular catheters, leaders, silver wire, physiological salt solution, and various instruments (scissors, Pean's ticks) are prepared (fig. 1).

This test started with introducing a straight catheter using the typical Seldinger's method into the abdominal aorta just above the division of the renal arteries of the anaesthetised patient. Aortonephography was done to provide images of the arteries leaving the aorta (fig. 2). After replacing the straight catheter with a flexible one (7F Cobra) without holes on either side, this was introduced into the suitable renal artery and 12-20 ml of contrast fluid (iohexol, Omnipaque-Nycomed) was given at a rate of 7-10 ml/s in order to get an arterionephrograph of the kidney. Then pictures were taken by a seriograph (8 photos in 10 s) to get a view of 3 phases: arterial, indirect, and venous (fig. 3, 4).

All the radiograms were discussed with a urologist, after which we started embolisation. Our device was fixed to a vascular catheter. Corks of spongostan, marked with a silver clip and rolled up in small rolls, were applied to the device. The corks were pushed towards the embolised kidney through the artery by using the physiological salt solution (we used 20 ml syringes). We could observe their movement on the screen thanks to the silver clip tied to the end of the cork. From 4 to 12 (average 7) corks were introduced into the patient. It was necessary in some patients to complete the occlusion of the artery with spongostan pulp and pieces of dexon thread (length 2-4 mm). This was inserted using a 5 ml syringe through the catheter installed in the renal artery. In cases where the kidney was supplied by more than one artery, a catheter was introduced into each of them.

We checked the artery during the process by adding a small amount of contrast fluid through the catheter. Apart from this, embolisation was checked thanks to the silver clips affixed to the spongostan corks. The process was finished when all the main branches of the renal artery were closed and contrast fluid floated from the renal artery into the aorta. After completing the process of embolisation, 2 ml of contrast fluid were given for 1 s and two pictures were taken 1 second apart. Wanting to see the endings of the vessels which had been embolised and the shadows of the metal parts of the corks, 10 ml of contrast fluid was given at a rate of 7 ml per second through the catheter placed in the abdominal aorta just above the embolised vessel (2 pictures were taken 1 sec apart).

In the event of pain, 2 ml of a 2% solution of xylocaine was administered through the catheter, and the effects were clearly noticed. During, palliative embolisation, smaller spongostan corks were used (size 35 mm x 1 mm x 1 mm), only some of which were marked with silver clips. The vessels were always filled with spongostan pulp prepared with dexon (fig. 5). Next, a Gianturco coil was installed in the renal artery: this prolonged the process of re-canalisation, but we were able to embolise the same kidney once more. After the procedure, the patients were sent to the Urological Department.

Blood pressure was measured four times after the operation, every two hours, then every hour.

Table I
The number of patients dependent on size of tumor.
Liczba pacjentów zależności od rozmiaru guza.

Degree of tumor progression	Number of patients
T0	–
T1	19
T2	16
T3	15
T4	22
Together	72

Table II
Presence of distant metastases.
Obecność odległych przerzutów.

Organ with metastases	Number of patients
lungs	17
mediastinum	6
hepar	21
bones	7
the second kidney	1
distant lymph nodes	19
pancreas	2
brain	3
spleen	1
adrenal gland	2

Table III
Average time of nephrectomy (in minutes).
Średni czas trwania nefrektomii (w minutach).

Tumor progression degree	Average time of nephrectomy after embolisation	Average time of nephrectomy without embolisation
T1	83	90
T2	105	112
T3	121	135
T4	160	185

Blood pressure and pulse were constantly monitored while the patients were in the hospital (patients with the palliative procedure were released 4-5 days after embolisation). Temperature was measured every day, and we also checked for post-embolisation syndrom. After 4 hours the pressure dressing was loosened, and after 24 hours removed. Urine analysis, blood morphology, BS, serum level of creatinine, and urine were tested 3 days after the procedure among the patients who had had palliative embolisation. Ultrasonographic examination of the abdominal cavity was also conducted. All the patients had suffered from tumours of stages T3 and T4 before nephrectomy. The sizes of the tumours were compared with estimates before the operation (according to TNM). The tightness of the embolisation, collateral circulation, ischaemia of the kidneys, duration of the procedure, and blood transfusion were estimated. Patients who were not operated were controlled every 3 months; urine analysis, blood morphology, USG of the abdominal cavity, and X-ray examination of the chest were done. Every 6 months, a CT scan of the abdominal cavity was performed. We estimated the grade of ischaemia of the kidneys and the state of the neighbourig organs. The rest of the patients were tested every 3 months in order to monitor the site after nephrectomy and to check all the organs of the abdominal cavity.

Table IV
Number of nephrectomy with blood transfusion and without blood transfusion.
Liczba nefrektomii z lub bez konieczności przetaczania krwi.

Tumor progression degree	Number of operations without blood transfusion	Number of operations with blood transfusion
T1	15	2
T2	7	8
T3	3	7
T4	1	1
Together	26	18

Table V
Patients and survival times.
Czas przeżycia chorych po embolizacji i nefrektomii oraz po embolizacji paliatywnej.

Tumor progression degree	After embolisation and nephrectomy	After palliative embolisation
T1	55 months	40 months
T2	41 months	27 months
T3	22 months	13 months
T4	15 months	11 months

Table VI
Side-effects in 72 cases after performed embolisations.
Objawy niepożądane po wykonanych embolizacjach u 72 chorych.

Side-effects	Number of patients under embolisation	Percentage of patients under embolisation
pain	64	89%
high arterial pressure	51	70%
high temperature of body	66	91%
nausea and vomiting	18	25%
anxiety, restlessness, nervousness	23	32%
excessive thirst	58	80%

Results

The largest number of patients who took part in this procedure were those with tumours: at stage T4 there were 22, then T1 with 19, and T2 with 16. The smallest group, with 15 patients, had tumours at stage T3 (table I).

Tumour volume was estimated according to CT examination and anatomopathologic examination. Tumour sizes varied from 1.5 cm to 32 cm. The presence of metastases in the retroperitoneal lymphatic nodes was established by CT and histopathological examination. 45 patients had at least one enlarged lymphatic node. The largest groups of patients were groups N3 and N4,

with16 patients in each. Estimation by CT examination was not highly characteristic as it creates a lymphonodus reaction not always connected with the existence of tumour. In a group of 36 patients we noticed distant metastases. We found these on the liver (21 patients), lymphatic nodes (19 patients), and lungs (17 patients) [9]. These data are the same as those reported in the literature [10]. One of the patients had distant metastasis in the other kidney, another (after nephrectomy) had a metastasis in the brain. After removing the metastases we performed embolisation and nephrectomy (table II).

The majority of patients were 50 - 60 and 60-70 years old (the data are the same as in the literature) [11]. The predominance of men to women in our group (5:2) was connected with the fact that we are a military hospital and men comprise the larger group of patients. A slight predominance of tumours of the right kidney may be the result of statistical error. At stage T1 we performed 17 embolisations before operating, at T2 15, at T3 10, and at T4 2. We performed 21 palliative embolisations at stage T4 [12,13]. The average time of the procedure was shortened by about approximately 30% compared with the classical method (inserting corks of up to 15 cm long), lasting (together with vessel examination) 65 minutes, whereas the classical method lasts 105 minutes. Palliative embolisation lasted approximately 128 minutes. We were able to achieve such a short time of the procedure thanks to our own method of inserting large corks of spongostan to close the lobular and segmental vessels and insulating the vascular bed with spongostan-dexon pulp.

The time of removing a kidney depended on the size of the tumour, anatomical circumstances, and the surgeon [14]. We especially shortened the time of operation about 15 minutes when we removed tumours at stages T3 and T4 (the operations were performed by the same team of surgeons). (table III)

Embolisation before nephrectomy enables one to limit the amount of blood transfusion by up to 150-200 ml during a simple nephrectomy. This means that the amount of blood was one fourth that of a group of patients where nephrectomy was carried out without embolisation [15,16,25]. In a group of our patients, 26 out of 44 were not given any blood, but only physiological liquids [15]. 18 patients were each given 0.8 units of erythrocyte concentrate during nephrectomy. Blood transfusion took place in these cases because, apart from tumours, other parts of infiltrated tissues were removed. Patients who were operated without embolisation were only occasionally not given any blood (table IV).

We compared survival times of patients after embolisation and nephrectomy and after palliative embolisation. The average survival time of patients with tumour stage T1 after embolisation and nephrectomy was 55 months and after palliative embolisation 40 months. At stage T2 these were 41 and 27 months, at T3 22 and 13 months, and at T4 15 and 11 months, respectively (table V).

As we can see, at stages T1 and T2 embolisation and nephrectomy are more

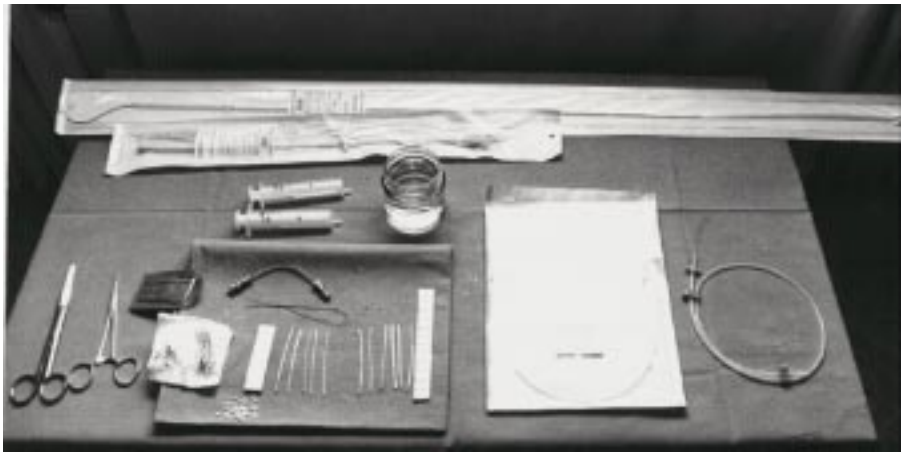

Figure 1
Embolisation set.
Zestaw przygotowany do embolizacji.

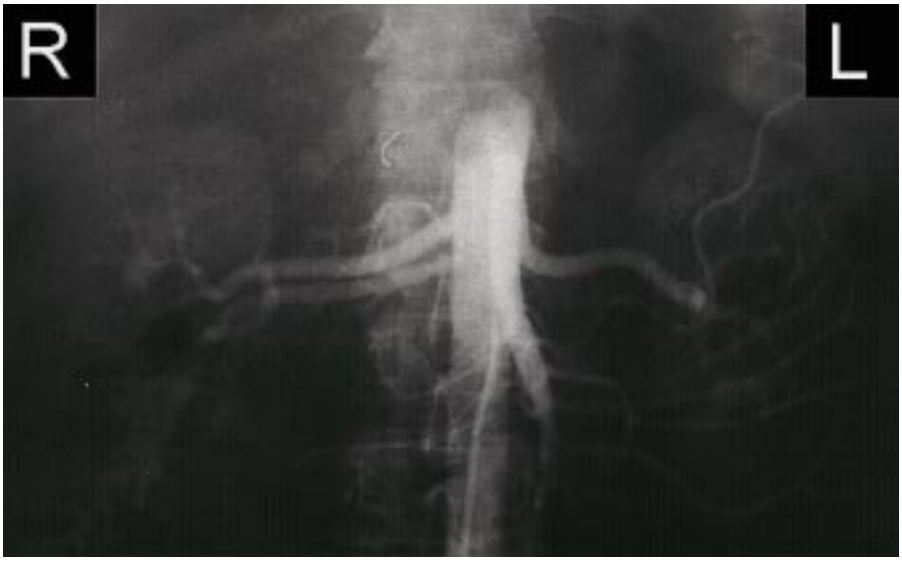

Figure 2
Aortonephrography.
Aortonefrografia metodą Seldingera.

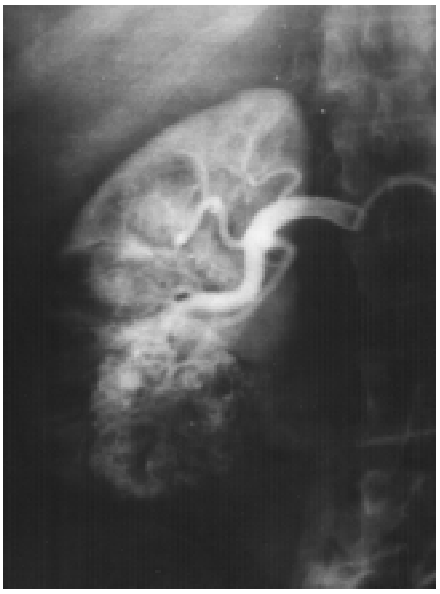

Figure 3
Tumor of the right kidney (renal cell carcinoma). Arterionephrography before embolisation.
Guz nerki prawej (rak jasnokomórkowy). Angiografia wybiórcza tętnicy nerkowej przed zabiegiem operacyjnym.

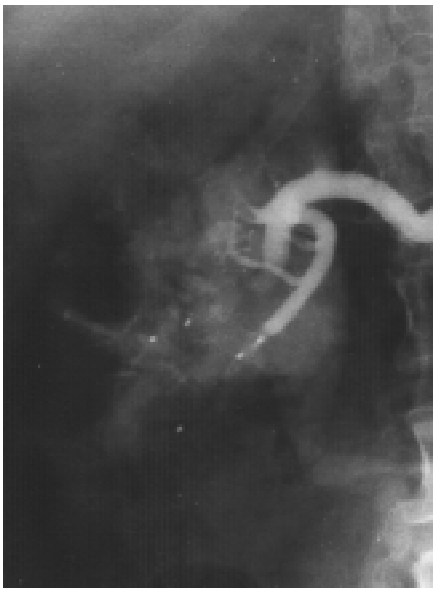

Figure 4
This same kidney after embolisation. Arterial phase of arterionephrography. Marking the corks with silver clips enabled us to follow the distribution of the corks in the kidney that was embolised by fluoroscopy.
Ta sama co na rycinie 3 nerka po embolizacji. Angiografia wybiórcza tętnicy nerkowej. Znakowanie korków spongostanowych klipsem srebrnym umożliwia podczas fluoroskopii kontrolę rozmieszczenia materiału embolizacyjnego.

efficient than palliative embolisation [17]. At stage T4 the difference between embolisation before nephrectomy and palliative embolisation is insignificant: the survival times of the patients are similar.

The reaction of the organism to renal infarction is called the post-embolisation syndrome [21,22,23]. The first symptoms, i.e. pain and nausea, appear during the procedure. The character and intensity of the symptoms depended on the material used, the extent of the area supplied by the closed artery, individual sensitivity, and the sort of contrast fluid used during embolisation. More common side-effect symptoms are:

- temperature over 37.5 0C - 91% of patients;
- lower-back pain – 98% of patients;
- excessive thirst (polydipsia) – 80% of patients;
- increased blood pressure – 70% of patients.

All these symptoms lasted up to 4 days after embolisation. The average increase in blood pressure was 20 mmHg, although 6 patients suffered from increases of about 60 mmHg. Just after 12 hours, blood pressure returned to normal. Elevated temperature was seen in 90% of patients and lasted for up to 4 days, varying between 370C and 38.70C. Polydipsia can be caused by high temperature and the stimulated excretion of the other kidney [5]. During the embolisation procedure, 9 patients out of 10 felt an intensification of pain. Smaller tumours caused a greater intensity of pain (due to the fact that there was more healthy kidney parenchyma). We relieved pain (which sometimes lasted up to 72 hours) with analgesic drugs, often narcotic ones. 8 patients felt almost nothing, due to the fact that almost their whole kidney was infiltrated by tumour. Side-effects after performed embolisation (table VI).

Post-embolisation syndrome lasts for up to 5 days after the procedure [13]. If it lasts longer, it means that we should take into consideration the possibility of postoperative complications appearing [5,19].

Some of these are:

- ischaemia tissues of kidney;
- abscess of abdominal organs, for instance the spleen
- damage to the embolised vessel.

There were 3 complications among our patients. In 2 cases there was massive bleeding at the site of needle insertion. This was probably caused by improper application of the compression dressing in one case and by incorrect position after the procedure in the other. In the third case an abscess of the embolised kidney appeared, which forced the urologists to open the abdominal cavity and remove the kidney (in spite of the fact that the embolisation was intended to be palliative). Lethal complications occurred rarely, i.e. in 1% of patients. During our procedure only one patient died (1.4%), eight hours after embolisation, because of myocardial infarction, confirmed by post mortem examination.

We could fill the vascular bed (which had not been completely closed earlier) with spongostan-dexon pulp without fear of the forces of the venous circulation because we could monitor the movement of the marked spongostan corks and the filling of the arteriovenous fistulas with fluoroscopy. Despite the fact that there were several fistulas in the embolised kidneys, large corks never managed to find their way through the venous system. Only once did a spongostan cork get stuck in the catheter, and when we tried to remove it, it got caught in the gluteal artery. Infarct of the organ never occurred using the suggested material. However, temporary paraparesis occurred twice, disappearing in 48 hours.

The simplicity of this novel technique, the possibility of using typical catheters, and the demonstrated high efficiency allow us to considered it as highly effective in the preoperative process of the patient [17,18]. This method is less useful in the case of palliative embolisation in view of the sufficiently rapid recanalisation of embolised vessels. However, there are some advantages of using this method: it can be repeated and it is considerably inexpensive. According to our own research and scientific literature [20], the embolisation material used in palliative embolisation of the kidney should be more permanent. A Gianturco coil can be installed at least in the main renal artery.

1. Direct results – embolisation before operation

- shortening of operation time by about 30% (in comparable circumstances);
- improvement of the operation conditions - 40 patients;
- elimination of the necessity of blood transfusion during nephrectomy – 26 patients;
- decrease in pain – 32 patients;
- diminishing of tumour after embolisation – 22 patients (according to USG of the abdominal cavity);
- prevention of the dissemination of neoplastic material.

2. Direct results – palliative embolisation

- soothing or alleviation of pain – 25 patients;
- regression or diminishing of haematuria – 23 patients;
- diminishing of tumour – 7 patients (according to USG results of the abdominal cavity 3 or 4 days after embolisation);
- improved general feeling – 17 patients.

3. Distant results – palliative embolisation

- soothing of pain;
- regression or diminishing of haematuria;
- limitation of tumour development (after 3 months we found during USG examination a diminishing of tumour size in 22 patients);
- growth inhibition of metastases (3 months after palliative embolisation we found in 3 out of 28 patients growth of metastasis, 2 in the liver, 1 in the lung);
- elimination of anaemia (stabilisation of blood morphology over comparable periods: the day of release from hospital, and 1 month and 3 months after embolisation);
- improvement of general feeling.

Discussion

In this study we analysed the course of treatment of 72 patients with renal cancer using our novel technique of embolisation. We estimated its efficiency and influence on the treatment effects. Our method enables us to embolise each vessel that delivers blood to the kidney. Using large corks of spongostan, we achieve the possibility and certainty of closing all arteriovenous fistulas. It is also possible to close fistulas using other materials, such as balloons, springs or coils, or metal balls, but all of these are considerably more expensive and demand suitable catheters, which we can find in sets used during embolisation [2]. As far as we know, the effects of embolisation are better if we use permanent materials, but we cannot repeat their use. Coils, springs, and the like should be used in palliative procedures because they meet permanent material demands [24]. At the beginning of the embolisation process, we filled all arteriovenous fistulas with large corks of spongostan or with coils, springs, or balloons. In this way we prevented pulmonary or other embolism of arteries with the embolisation material. However, by a considerably advanced development of tumour and fully developed collateral circulation, it is difficult to close the necessary fistulas. In this case we embolised the arteries inside the kidney with large corks of spongostan which cannot (because of their size) force their way through the arteriovenous fistulas. After installing a Gianturco coil, embolisation of the same artery is impossible, but its effects are substantial: there is no recanalisation of the renal artery, but collateral circulation developed, originating from lumbar arteries, suprarenal glands, and vessels of neighbouring organs. We examined 8 patients with this coil a year later and it appeared that a large amount of collateral circulation had developed; however, the main branch of the renal artery was not recanalised .There is no possibility to perform embolisation again because of the small cross-section of the artery. However, there is a possibility to conduct the embolisation in small vessels using microcatheters [4].

A large group of patients, 44 out of 72, aged 22-72 years, underwent nephrectomy after embolisation. Embolisation was carried out with spongostan corks (70 mm x 1 mm x 1 mm) marked with silver clips. Preoperative embolisation was performed in order to simplify the nephrectomy, shorten the time of intervention, reduce bleeding, and avoid the necessity of blood transfusion. Embolisation blocks the dissemination of cancer and embolic materials during the operation. Embolisation closes the arteries which supply the kidney with blood, causing the veins to collapse, which clearly diminishes bleeding during the operation. It shortens the time of the procedure by eliminating the process of ligation of the vessels of the collateral blood circulation. Urologists have expressed a high opinion of the method of embolisation before nephrectomy described [1].

The order of ligating the renal arteries is facultative. Good embolisation was often achieved with short spongostan corks (35 mm x 1 mm x 1 mm) with additional insulation made of a pulp of spongostan containing dexon threads. In eight patients, whose tumours did not infiltrate other organs, a

Gianturco coil was installed in the main branch of the renal artery. To shorten the time of the procedure in palliative embolisation, only the last two corks were marked with silver clips.

Adding the spongostan-dexon pulp by palliative embolisation was done because the vessel was not completely filled with large corks and we needed a tightly sealed vessel to prolong the time of recanalisation. A large size of cork prevents it from being pushed into the venous circulation through fistulas. Marking corks with clips enables them to be observed in the kidney and helps to place them in the respective parts of it.

We never started the procedure with applying the spongostan pulp. We never applied the pulp when angiography showed large arteriovenous fistulas. Nephrectomy followed embolisation after 1-3 days. Two patients were operated after 2 weeks due to tumours, which were initially thought to be inoperable, diminished so much (in CT examination by 21% and 28%) that the operation was possible. Embolisation did not influence tumours with extensive necrosis (tumours poorly vascularised; on the other hand, it did influence well-vascularised tumours) [1]. The distinction between tumour mass and other tissues was especially well visible within three days after embolisation [1]. However, there was a large possibility of the appearance of collateral circulation when the length of time between embolisation and operation was greater. The sources of this circulation were various: lumbar arteries, suprarenal glands, and mesenteric arteries. We think that the streamlined period for nephrectomy varies from 1 to 3 days after embolisation. The time of the procedure was prolonged to up to 128 minutes because we had to use twice the number of corks (size 35 mm x 1 mm x 1 mm), seal the vessels additionally, and install a Gianturco coil. In the event of recanalisation, we can repeat the embolisation.

Several of our patients were embolised twice, and two were embolised four times: a 64-year-old woman with a tumour in the left kidney and single metastases in the lung and liver, and a 57-year-old man with a tumour in the right kidney and metastases in the lung and brain. In the first case we repeated the embolisation after 7 months to stop haematuria, which was caused by a renewed neoplastic process. A third procedure was conducted 8 months later, also because of haematuria. During this time the number of round shadows in the lungs and metastatic foci in the liver increased. The patient died 22 months after the first embolisation in our hospital. A man was embolised three times, and haematuria stopped after each procedure. The second embolisation was made 4 months after the first one, and the third one 6 months later. The patient was under observation for 13 months, and died at home.

Correct diagnosis of tumours is essential in the process of qualification for embolisation, which is why we examined our patients using US, urography, scintigraphy, and CT examination [2]. Just before embolisation we performed angiography. In six cases we did not perform embolisation because the angiograph was unclear and we could not characterise the tumour [3]. Biopsy and a histopathological examination provided the explanation: it was renal cell carcinoma with much necrosis in the central part of the tumour (which was why we could not find any vessels). Twice it was angiomyolipoma and once adenocarcinoma. All patients who had undergone embolisation were examined with angiography and the results were confirmed by histopathological examination [3,4].

During our treatment, 28 patients were rejected due to poor somatic conditions and extensive cancerous lesions. They were 38-80 years old, and all suffered from pain (with different intensities), most often lumbar. Three patients suffered from typical neuralgia syndrome. Almost all were treated because of spinal disease at the first stage. 21 patients suffered from haematuria or erythrocyturia. There were often no typical and characteristic syndromes which were actually diagnosed. We can diagnose patients only by gathering the medical history, laboratory investigation, and radiological examination. We performed embolisation to stop haematuria, eliminate pain, and stop (or slow down) the development of tumour and prevent metastases [5]. We analysed the size of the tumour, the extent of vascularisation, the presence of distant metastases [6], and the number of arteries delivering blood to the kidney. During the embolisation procedure we took into account the size and kind of material used (spongostan and spongostan with dexon pulp), the size of the corks, and the time of embolisation, including arterial examination.

Conclusions

a. Shortening the time of embolisation

We shortened the time of the procedure because we used large corks of spongostan, of which we only needed a few to close large segmentary arteries. The unfilled part of the vascular bed we blocked with spongostan-dexon pulp.

b. Clearly visible distribution of corks

Marking the corks with silver clips enabled us to follow the distribution of the corks in the kidney that was embolised by fluoroscopy.

c. Safety

The size of the corks (35-70 mm) prevented them from threading their way to the venous circulation through arteriovenous fistulas. Corks which are too small often block venous circulation (for example in the lungs).

d. Tightness of embolisation

Additional filling of the vascular bed with spongostan and dexon pulp enabled us to diminish the rate of development of collateral circulation: dexon infiltrates into the vessels of the renal cortex.

e. Low cost of the procedure

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