CLASSICS OF BIOLOGY AND MEDICINE — II

Anastomosis of Blood Vessels by the Patching Method and Transplantation of the Kidney

Alexis Carrel and C.C. Guthrie

Hull Physiological Laboratory, University of Chicago, Chicago, Illinois

DEFINITIONS

The patching consists of closing an opening in the wall of a vessel by fitting and sewing to its edges a flap taken from another vessel or from some other structure such as the peritoneum [1]. For example, a portion of the wall of a carotid artery may be removed and the opening thus produced closed by a patch taken from the external jugular vein.

The anastomosis by the patching method consists of extirpating a vessel together with an area or patch from the vessel of origin, the patch being so cut that the mouth of the extirpated vessel is situated in the center of the patch. The edges of the patch are then fixed to the edges of a suitable opening made in the wall of another vessel. For example, a spermatic artery of a dog was dissected and removed with a triangular patch of the wall of the aorta surrounding its mouth. The edges of this patch were then sutured to the edges of a suitable opening, made in one of the femoral arteries. The spermatic artery was thus anastomosed to the wall of the femoral artery (Figure 1).

AIM

We have attempted to develop a method of anastomosing blood vessels so that even in case of slightly imperfect technic resulting in the deposition of fibrin on the lines of suture, the circulation would not be disturbed.

In methods hitherto employed, a fault of technic was sufficient to cause hindrance or even stoppage of the circulation. In the simple transplantation of the kidney, for instance, the wall of the renal vessels is cut and sutured. Then it happens that, in case of infection, or fault of technic, fibrin deposits itself on the line of suture and occludes the lumen of the vessel, that gangrene or atrophy of the organ are very liable to result.

In the anastomosis by the patching method the wall of the renal vessels is respected. Instead of cutting the vessels themselves, we extirpate a patch of the aorta and vena cava, in the center of which is located the mouth of the vessel. The edges of the flap are sutured to the edges of the aortic opening. If infection occurs, a clot can be produced on the line of suture. But this suture is located far from the

a Reprinted from the Journal of the American Medical Association 47:1648-1651, 1906.
mout of the renal artery. Thus, the circulation of the renal artery is not troubled. As regards the aorta, a small clot adherent to its wall does not disturb its circulation. Occurrence of gangrene in the transplanted organs is then almost impossible.

TECHNIC

The operation may be divided into two stages: 1. Preparation of the vessel to be transplanted and, 2, transplantation on the second vessel. For example, the anastomosis of the renal artery to the aorta in the transplantation of the kidney will be described.

1. Preparation of the renal artery and aortic patch

The aorta of the first animal is dissected to the level of the mouth of the renal artery. The renal artery, however, is not dissected. A patch of the aorta (Figure 2) surrounding the mouth of the renal artery is cut with scissors. The patch should be triangular or elliptic in shape and the edges as regular as possible in order that a smooth anastomosis can be made.

2. Transplantation of the patch on the wall of the aorta of the second animal

The aorta of the second animal is dissected between the mouths of the renal and genital arteries. The vessel being temporarily occluded both above and below, with one cut of the scissors an elliptic opening a little longer than the patch taken from the first animal is made in the wall of the aorta. Each end of the patch is then fixed to the ends of the aortic opening by a single stitch (Figure 3). The edges of the patch and of the aortic opening are then united by a continuous suture (Figure 4).

Anastomosis of the renal vein to the vena cava is performed in the same manner.

The circulation is re-established by releasing the vessels where they were temporarily occluded. The blood penetrates immediately through the renal artery into...
the capillaries of the organ and returns
through the renal vein to the vena cava.

At the line of suture of the aorta a lit-
tle blood may escape. This hemorrhage
ordinarily stops of itself within one or two
minutes, but if it continues it is easily con-
trolled by one or two supplementary
stitches. The operation is less difficult on
the veins owing to their greater flexibility.
For this reason the line of suturing on the
vena cava is usually blood proof.

The same method is well adapted to
the anastomosis of the ovarian, spermatic,
and other vessels.

RESULTS

This method has been employed on
cats and dogs in fourteen cases of trans-
plantation of the kidney, in one case of trans-
plantation of the ovary, in several
experiments of simple patching (i.e.,
repairing openings in walls of arteries by
flaps of vein or peritoneum) and in some
experiments in which the animals were
killed at the end of a few hours, such as the
transplanting the head of an animal in the
abdominal region of another animal.

Although infection often occurred,
the circulation in the organs has nearly
always been good, and in no case gangrene
of the transplanted organ (kidney or ovary)
has been observed.

(a) Anatomic results

Within a few days after the operation,
the stitches placed in making the anasto-
omoses became covered with a glistening
substance similar in appearance to the nor-
mal endothelium. In some cases there was
a very small ribbon-like deposit of fibrin
around the line of anastomosis. Irregularly
shaped clots sometimes occurred at points
of defective union of the intimas. In a dog
that died eight days after the operation
from diffuse phlegmon of the abdominal
wall, a clot was found tightly adherent to
one of the ends of the patch. But the sur-
face of the patch was smooth and the
mouth of the renal artery was entirely

Figure 3. 1, Aorta of the second animal; 2, renal artery; 2', mouth of the renal artery; 3, patch taken from the aorta of the first animal; 4, aortic opening; 5, threads uniting the ends of the patch and of the aortic opening.

Figure 4. 1, Aorta of the second animal; 2, renal artery; 3, patch of the aorta of the first animal; 4, continuous suture.
unobstructed and normal in appearance. If such infection had occurred in a termino-terminal (Figure 5) or termino-lateral anastomosis, obliteration of the vessel would probably have occurred. By the patching method, however, this accident had practically no effect on the circulation either in the aorta or in the renal artery (Figure 6).

Anatomic union of the wall and the patch may occur rapidly after the operation. For example, fifteen days after transplanting the ovary of a pregnant cat into a small male kitten, it was practically impossible to distinguish the line of union of the patch of vena cava of the former to the wall of the vena cava of the latter. Also the union of the arterial anastomosis was excellent, the endothelium being smooth and glistening, but it was possible to distinguish the outline of the transplanted aortic patch. In some other cases small deposits of fibrin were observed on the line of the suture. They were very thin and, of course, did not interfere at all with the circulation. Specimens taken eight days, ten days, eighteen days, twenty-seven days, forty-three days (Figure 7) after the operation, and one taken five months after, show that the results remain excellent for these periods.

(b) Physiologic results

As soon as the blood is allowed to flow through the aorta, the circulation of the renal artery is re-established and appears to be practically normal. The renal vessels are surrounded by their connective tissue and protected by the peritoneum. Their caliber and their appearance are not modified. The kidney is a little redder, harder and enlarged.

Such animals walk, climb, jump, and, in fact, comport themselves in a manner very like the normal the day following the operation and even, in some cases, within a few hours after the operation.

A cat into which a kidney had been transplanted was anesthetized eight days after the operation and its abdominal cavity...
opened by a transverse incision a little above the renal vessels. The transplanted kidney was found covered by glistening peritoneum without intestinal adherences. The color of the kidney was a little redder, but practically normal; the organ was slightly increased in size. The circulation was excellent and even greater than before the operation. The only evidence of the operation was a bulging of the aorta and the vena cava at the point of anastomosis of the renal vessels. The excellence of the physiologic result was presumably in a large measure due to the insignificant alteration of the condition of the renal vessels and the ureter from the normal.

A female cat [exhibited before the Section of Physiology of the meeting of the British Medical Association, Toronto, August, 1906], to which a kidney from another cat was transplanted four months ago, is now living in good health. The transplanted kidney is enlarged. Its consistency is a little harder and its form is normal. By palpation the pulsations of the renal artery are easily detected and appear to be normal.

These observations show that the results of the anastomoses by the patching method remain good for a long period.

**CONCLUSIONS**

1. By the patching method, the termino-lateral anastomosis of blood vessels is more safely performed than by the other methods.

2. It prevents the occurrence of gangrene after the transplantation of organs even in case of slight infection.

3. The circulation of a kidney, transplanted with anastomosis of its vessels by the patching method, is excellent four months after the operation.

**REFERENCE**

1. Carrel and Guthrie. Resultant du patching des artères. Comptes rendus de la Société de biologie de Paris, June 22, 1906.