U. M.

THE UNIVERSITY OF MINNESOTA

GRADUATE SCHOOL

Report

of

Committee on Thesis

The undersigned, acting as a Committee of the Graduate School, have read the accompanying thesis submitted by Carleton Dederer for the degree of ~~Doctor~~ Master Science of ~~Philosophy~~ Experimental in Surgery. They approve it as a thesis meeting the requirements of the Graduate School of the University of Minnesota, and recommend that it be accepted in partial fulfillment of the requirements for the degree of ~~Doctor~~ Master of ~~Philosophy~~ Science in Experimental Surgery.

A. C. Ballon
Chairman

W. F. Braasch

E. T. Bell.

May 30 1918

Arthur T. Mann, M.D.

THE UNIVERSITY OF MINNESOTA

GRADUATE SCHOOL

Report

of

Committee on Examination

This is to certify that we the undersigned, as a committee of the Graduate School, have given Carleton Dederer final oral examination for the degree of Master of Science in Experimental Surgery. We recommend that the degree of Master of Science in Experimental Surgery be conferred upon the candidate.

Minneapolis, Minnesota

May 30 1919

D. C. Balfour
Chairman

W. F. Braasch

F. C. Mann

J. F. Corbett

Wm Carpenter MacCarty

H. E. Robertson

E. T. Bell

A. C. Strachauer

THESIS

TRANSPLANTATION OF THE KIDNEY AND THE OVARY

Carleton Dederer

Submitted to the Graduate Faculty of the
University of Minnesota
in Partial Fulfillment of the
requirements for the degree of
Master of Science
in
Experimental Surgery

June
1919

INTRODUCTION

My ultimate purpose in doing this work is to endeavor to find a means of successfully transplanting into a person a necessary organ of which he has been deprived. My immediate purpose is to attempt to improve our present knowledge of this mysterious subject. However, as to the practical application of the method it may be said that the "hem of the garment" has yet to be touched.

It may be stated that the early reports of experiments in this field have shown an absence of consideration of the fundamental principle that the success in transplanting an organ from one animal to another depends on the closeness of the relationship of the animals.

A distinction should be made between the terms "graft" and "transplant". The term graft means to transfer to contraposition tissues or organs viably in contact with other tissues or organs but without vascular anastomosis. Transplant means to completely remove an organ or portion thereof to a new position, with reestablishment of its circulation through vascular anastomosis. The term autotransplant means to transplant in the same animal. Homotransplant means to transplant from one animal to another of the same species. Heterotransplant means to transplant from one animal to another of different species. Reimplantation means to implant the organ back into the original location. Different vessels may be used. For example the kidney may be re-implanted into the abdomen, using the splenic vessels which are longer than the renal vessels. With reference to the immediate position of the kidney this procedure could also be called a transplantation.

DATA FROM THE LITERATURE

Murphy, in 1897, was the first to report the use of the end-to-end suture of blood vessels in human surgery by means of the "over and over" stitch. He mentions other methods of joining the vessels, particularly that of invagination and suture. This was to furnish continuity of the intimal lining in the blood vessels. However, the end-to-end suture has remained the accepted procedure until the present time.

Dörfler, in 1899, experimented with the Murphy method of invagination. He had 12 positive results in 20 experiments. The finest intestinal needles, and the running stitch of the finest silk thread were used. He was careful to avoid injury from pinchers. In working on the human carotid artery he used only the two outer vascular coats, but on the brachial artery he found it safer to include all three coats. Dörfler stated that Murphy used three retaining sutures, and rubber covered Billroth clamps. He quotes the work of different authors as follows:

In 1762 Lambert succeeded in suturing an artery in a horse. In 1773, Assmann discredited blood vessel suture by negative experimental results. In 1861 Czerny closed a wound in the internal jugular; the negative results were credited to infection. In 1889 Jassinowsky succeeded in arterial suture, and set down as requisites for closing small caliber vessels the gentlest handling of the vessel wall, suture through the adventitia and media, and the use of the finest silk. He controlled the after bleeding by a little pressure on the suture line. Bruci, in 1889, also succeeded in arterial suture. He recognized internal and external white thrombus which later became fully organized. Schede, in 1892, sutured the inferior vena cava. Heidenhain sutured the axillary artery in 1894.

Also in 1894 Muscatello twice successfully sutured the aorta in the dog. Gluck used rings of aluminum, silver and ivory, and circular suture to unite the carotid artery to the jugular vein (experimental). Abbe as well as Gluck placed glass tubes in vessels to unite them.

Payr, in 1900, published an article on the technic of blood vessel and nerve suture. Figure 1 shows a vessel with three sutures in the edge to pull the walls apart and a magnesium tube used for the accomplishment of the anastomosis.

In 1902, Ullmann transplanted a dog's kidney to the neck, using magnesium tubes, the kidney having been immersed in warm salt solution. One dog lived ten days without the removal of the good kidney. The chief difficulty experienced was the retraction of the ureter from scratching or from other cause, and the flow of urine into the wound. The failure is attributed to conditions in the laboratory. Ureteral contractions, the quantity and character of the urine were not mentioned. Excretion was present five days.

Decastello, in 1902, in performing homotransplant with the kidney placed in the renal position, found that 1200 c.c. of urine were excreted in forty hours. The urine did not contain red cells but was rich in albumin and casts.

In 1902, Carrel modified the Murphy technic by using No.14 needles and a dark background to make it easier to see the sutures. He also used three sutures for the purpose of holding the vessel walls apart while working on them.

Carrel in 1907 reported the transplantation of one kidney to the neck. The animal died in three days. The transplantation was also done with

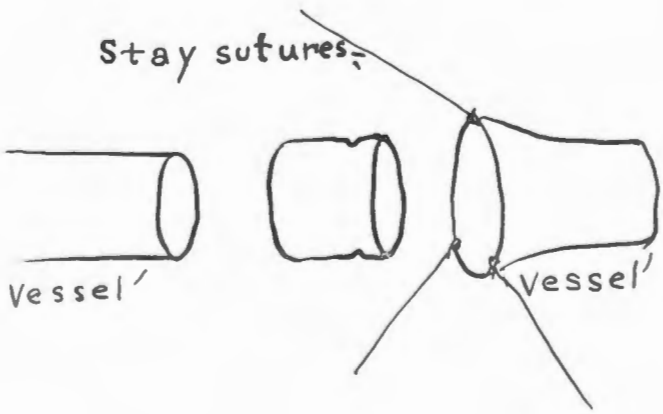

Fig. 1. One end of a vessel becomes invaginated into the other by means of a magnesium tube and stay sutures to hold the vessel walls apart (after Payr).

fatal results within forty-eight hours after removal of the good kidney. Carrel mentioned also a homoplastic transplant of kidneys in mass in which the animal died on the tenth day. Right ovarian transplantation was attempted but no successful case was reported; the experiment was done only for the development of technic. Transplantation of the heart, which was tried under septic conditions, had to be abandoned. However cardiac contractions were demonstrated. Transplantation of the thyroid was attempted but it failed owing to "bad aseptic and technical conditions." Carrel credits Ullmann with having made the first transplantation of the kidney.

Carrel in 1908 reported experiments in homotransplantation of the kidney but in all of these some fatal complication ensued. The cat was the animal to live the longest. One lived till the thirty-sixth day and died of what Carrel described as "acute calcification of the arteries."

Carrel in 1909 in an article on reimplantation of an extirpated kidney mentioned the use of No. 16 needles and black Japanese silk. There was no difficulty in reimplanting the extirpated kidney. This operation and nephrectomy of the other kidney was performed on one dog which was living at the time of the report, eight months later. Carrel's best time record was made in one operation which lasted two hours and twenty minutes. He stated that the kidney in this operation was out of circulation thirty-eight minutes.

Jensen, in 1903, reported the use of two methods of ring anastomosis of blood vessels which produced eversion when the sutures were tied. He credited Murphy with being the first surgeon to use the circular suture for end-to-end anastomosis in man. He also mentions that Hallowell in 1759 closed a wound in an artery by suture.

Floresco, in 1905, found one of ten renal arteries in the dog to be bifurcated. He had never been able to establish circulation where the sectioning of the artery had been made close to the bifurcation. While transplanting one kidney into the position of a removed kidney it was necessary to stop the circulation for about an hour. Bringing the ureter through the skin resulted fatally from infection after three days; necrosis of the ureter was the first evidence. Also when the kidney was transplanted with ureteral anastomosis the dog lived but a few days. Floresco, after experimentally shutting off the renal blood stream for periods of a half hour and one hour, concluded that the one hour occlusion was contributory to the failure of operation. Having found experimentally that saline solution was bad for the kidneys he used liquid vaseline only for wrinsing the vessels. A homotransplant in a dog was performed using this method. On the second day suppuration occurred. On the sixth day the flow, which had been bloody, diminished, it ceased altogether on the eighth day. The necrosed kidney and ureter were removed, and the dog was saved for another experiment. In one operation in which a double nephrectomy with a single reimplantation of the dog's own kidney was done the dog lived eleven days. Floresco believes that retraction of the ureter is fatal. In one of his cases of a renal homotransplant with double nephrectomy, the dog lived only 165 hours. The injection of peptone solution was tried; this caused lack of coagulability and depression. Floresco discussed unsuccessful transplantation to the neck, and referred to the depth and location and trauma.

Stich, Makkas and Dowman, in 1907, in an article on circular anastomosis in blood vessel transplantation demonstrated the standard method of removing adventitia. Their illustrations show the twisted threads, the non-use of gloves, and the three-stay method of wall separation.

Stich, in 1913, in discussing the transplantation of organs spoke of the "Isolysinreaktionen" as the factor in the problem which has to be solved, as well as the interaction between the antibodies and foreign albumin. The problem of homotransplantation he thought was yet to be solved by "Arbeit in der Stille des Laboratoriums."

In 1908, Guthrie, in an article on some of the physiologic aspects of blood vessel surgery stated: "The technic employed in my experiments is a modification of that developed by Dr. Carrel and myself. Essentially it is the same as that employed by previous successful investigators in that it consists of gentle handling of the vessels, with protection from drying, smooth approximation of the intimal surfaces and fixation by means of needles and thread in proportion to the size of the vessel." Guthrie believes that because a transplanted limb is good for eleven days it is "justifiable" to conclude that such a condition could be permanent.

In 1910 Guthrie pointed out and showed experimentally the grave dangers of perfusing the kidneys with salt solution. Animals died within seven days after occlusion of the blood supply of the kidneys for from fourteen to eighteen minutes, and after perfusion with Locke's solution or salt solution for ten to twelve minutes.

In 1912, Guthrie, in an article on blood vessel surgery and its applications, stated that pulsation follows such operations as the fixed heterotransplants of blood vessels. He believes that transplantation of ovaries with reestablishment of the circulation is unnecessary because he has had success in grafting ovaries. He grafted the testicle also. In limb homotransplantation one of his dogs lived five days then died of infection. A transplant of the heart and lungs was attempted; the auricles and ventricles began beating, but

infection caused failure. Guthrie and Carrel made what was considered a successful autograft of the thyroid.

Unger in 1909, transplanted kidneys; he used the aorta and vena cava. The animals ("Katzen oder Hunde") lived as long as eighteen days. The kidneys showed hemorrhage and infaretion. One dog with homotransplanted kidneys lived six days.

In 1909 Borst and Enderlen found that the splenic vessels were best suited for the reimplantation of an extirpated kidney. One of their autoreimplants lived in the abdomen thirty-four days; another lived 118 days when the other kidney was removed one week after operation. In their homotransplantations of the kidney one transplant lasted fourteen days, the other eighteen days, with necrosis of the transplant in each case. In the remainder of the experiments the transplant lasted from one to two days.

Zaaijer, in 1910, reported the autotransplantation of the left kidney of a dog into the groin, making use of the femoral vessels, with grafting of the ureter into the wall of the bladder. The right kidney was removed later. The dog remained well indefinitely.

Villard and Tavernier, in 1910 reported the transplantation of a dog's left kidney to its neck without removal of the right kidney. They state that the dog died following "another" operation after sixty-eight days. In transplanting the kidney the circulation was interrupted for an hour and a half. In the two cases of homotransplantation they mention, the results were not conclusive. In the first case a rupture of a perirenal hematoma into the peritoneal cavity was fatal after the thirteenth day. The iliac vessels were used. In the second case the splenic vessels were used. Nephrectomy killed the dog

before the presence of any function was established.

Lobenhoffer, in 1913 made use of the splenic vessels in reimplanting the kidney into the abdomen.. He tried transplantation of the left kidney with right nephrectomy three times. All the dogs died soon after the operation.

Berheim, in 1913, in writing on surgery of the vascular system, stated that no set rule could be laid down as to the number of stitches in any one side of a triangle or in the whole triangle, that this must of necessity depend on the size of the vessels, but the sutures must neither be placed too close together nor too far apart.

Quinby, in 1916, reimplanted one kidney and subsequently removed the other. The circulation was stopped for one hour. The dog lived indefinitely.

The review of the literature showed that Murphy was the first to use the end-to-end method of blood vessel anastomosis in man. Several modifications of his technic have been described. Ullmann was the first to attempt the experimental surgical transplantation of an organ. Carrel first emphasized the use of artificial saline solutions in perfusing organs to be transplanted. Floresco first showed the dire effects of perfusion of an organ to be transplanted. Guthrie corroborated Floresco and found that perfusion of a kidney with saline solution produced slow death of the organ. The results of these two investigators indicate that a successful transplantation of a kidney cannot be made where the perfusion method is used.

PART I

AUTOTRANSPLANTATION OF THE KIDNEY

In 1917, after devoting several months to an experimental study of the elements of vascular suture, I attempted the autotransplantation in the dog of a kidney into the neck. After five partially successful operations complete success was attained.

May 2, 1917, the left kidney of dog B976 was transplanted into the neck by uniting the renal artery at its bifurcation with the common carotid artery, and the renal vein to the external jugular vein. Some of the details of this experiment have been published.[5] Two weeks after transplantation right nephrectomy was performed. The dog lived more than four months; it died as a result of hydronephrosis.

The physical signs of hydronephrosis in a kidney transplanted to the neck were now so well defined as a result of this experiment that in a similar case the condition could be readily diagnosed. The apparent enlargement of the kidney which had been secreting satisfactorily, as was easily observed in the neck, in conjunction with hypertrophy of the ureter, which was evidenced by strong squirting of a stream of urine away from the dog, and a ureteral orifice which was a normal pink, demonstrated that hydronephrosis had developed in the transplanted kidney.

Extract from protocol

Dog B976: August 18, 1917, 3 months and 16 days after the transplantation, and 3 months and 3 days after the second nephrectomy, analyses were made for comparison of the stream urine and of that which ran down the animal's neck:

Surface urine:	Stream urine:
amber	amber
cloudy	clear
slightly alkaline	very slightly alkaline (less change in the litmus paper)
no albumin	no albumin
epithelial cells	no cells or detritis
few leukocytes	
triple phosphates	
amorphous detritis	

August 27 the ureter protruded about 6 mm. Every ureteral contraction shot a stream of urine. Four cubic centimeters of urine could readily be obtained by pressure on the kidney.

August 30 a detailed examination was made of the state of the hydronephrosis.

8:15 p.m. The animal was quiet, not alert. The outside diameter of the kidney in the neck was 7.7 cm.

8:16 p.m. The ureter was opened by a slit about 1 cm. long. This resulted in the escape of more than 25 c.c. of urine which was tinged with blood from the incision.

8:25 p.m. The size of the kidney (external measurement) was 4.7 cm. including skin and fascia; the kidney being in its proper place in the neck.

8:34 p.m. Urine was being excreted 60 drops to the minute (about 5 c.c.).

8:49 p.m. 5 c.c. was excreted in one minute (57 drops), and a stream about 1 mm. in diameter could be pressed out.

8:58 p.m. The dog was standing quietly, not alert.

9:01 p.m. A specimen of urine (3 c.c.), showed it to be clear, alkaline with faint trace of albumin, and a few erythrocytes; no casts; no

epithelial cells; triple phosphates.

9:09 p.m. Its weight was 7.8 kg.

9:36 p.m. The weight was 7.7 kg. The dog had lost .1 kg. in 27 minutes, after the obstruction in the ureter had been slit open.

10:26 p.m. The dog came out of the dog house and stood around for a time and then returned. The urine was flowing freely and was clear.

Examination of a specimen of urine (25 c.c.) taken from the hydronephrotic autotransplanted kidney after the removal of the obstruction to the urinary flow, showed many erythrocytes (from the incision); albumin (due to hemorrhage); nitrogen of urea and ammonia per c.c., 5.69 mg. A specimen taken forty-five minutes later (3 c.c. in one minute) showed a few erythrocytes and triple phosphates; albumin a trace; nitrogen of urea and ammonia per c.c., 12.18 mg.

After this the dog wasted away and after an unsuccessful attempt to homotransplant a kidney the animal was sacrificed Sept 3, 1917. The transplant was made in one femoral region and no function resulted probably due to venous stasis from unavoidable vein kinking, and venous constriction.

Necropsy showed the autransplanted kidney in the neck to have a dilated pelvis and a markedly hypertrophied and dilated ureter (Figs. 2-16).

Fig. 2. Dog B976. Three weeks after a second nephrectomy, active and in good spirits. The dog depends on its own kidney which is in the neck. The ureter is healed to the skin, forming a new orifice for urinary excretion.

Fig. 5. Dog B976. Autotransplanted kidney, removed from its site of functional activity in the neck on the 125 th day.

Fig. 4. Dog B976. Same specimen as Figure 3. Hydronephrotic autotransplanted kidney after being removed from the neck on the 125 th day.

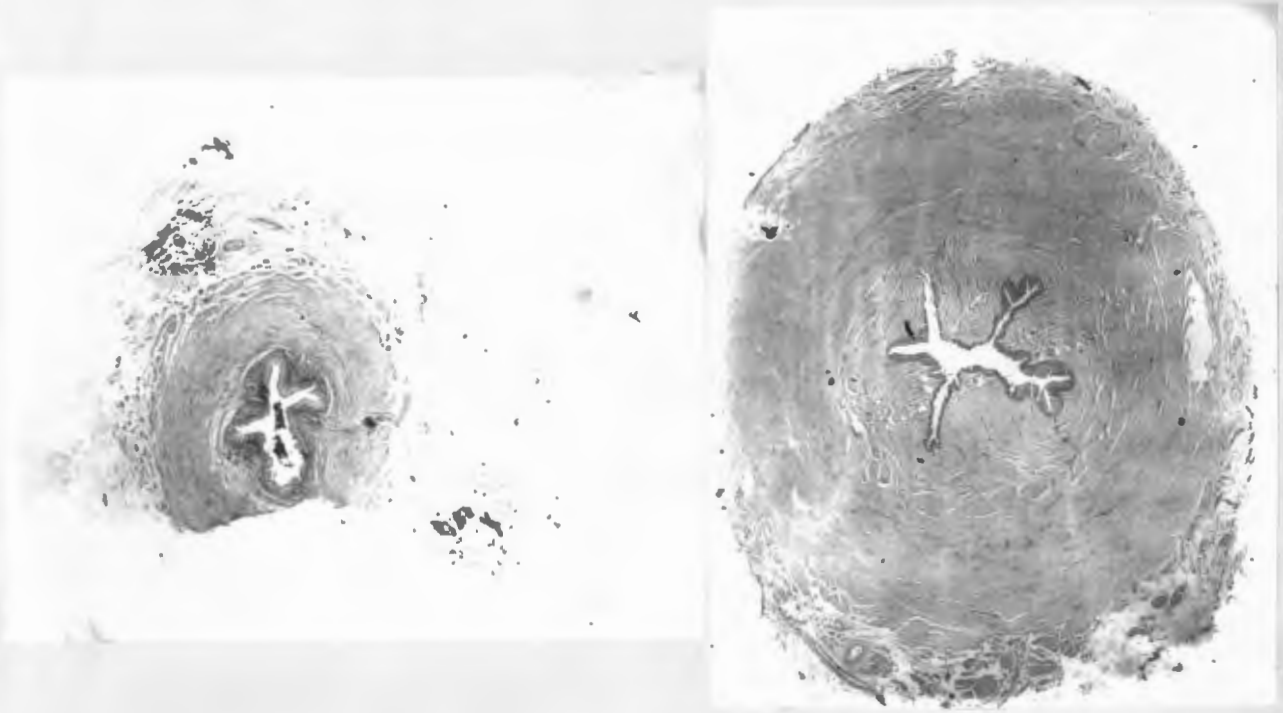

Fig. 5. Dog B976. Cross sections of the normal and the transplanted ureter on the 125 th day after operation showing enormous hypertrophy in the transplanted ureter due to the obstruction at the meatus in the skin. Each magnified equally. Paraffin, hematoxylin and eosin X15.

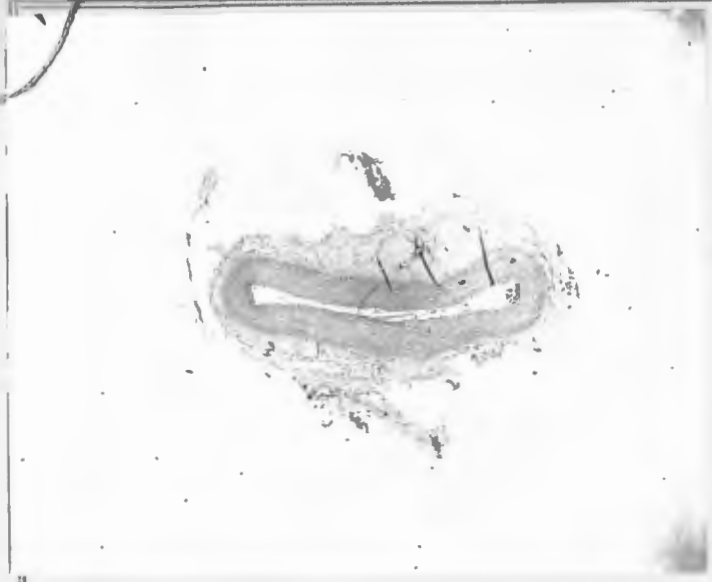

Fig. 6. Dog B976. Silk sutures in the renal artery at the site of anastomosis. Paraffin, hematoxylin and eosin X15.

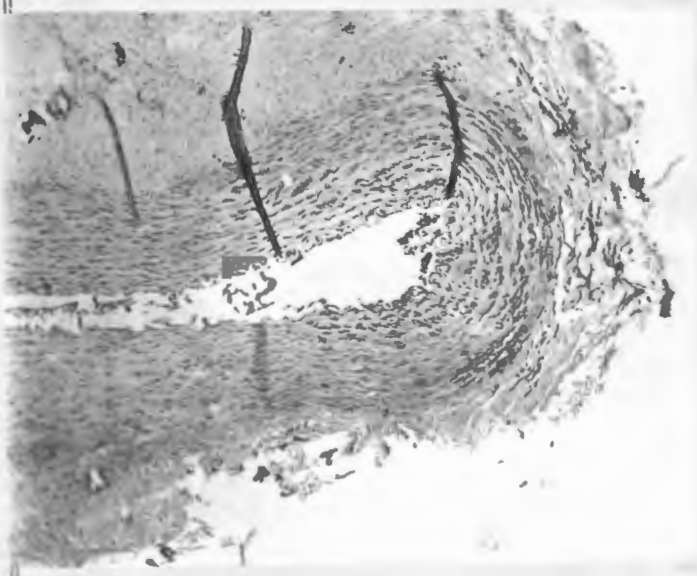

Fig. 7. Dog B976. Renal artery at site of anastomosis. Paraffin, hematoxylin and eosin X50.

Fig. 8. Dog B976. Silk suture material at the site of anastomosis on the 125 th day after renal autotransplant. Paraffin, hematoxylin and eosin X900.

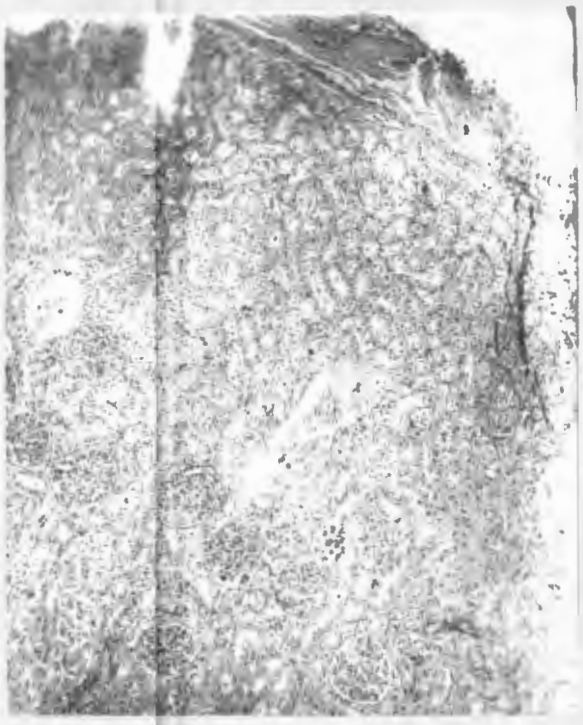

Fig. 9. Dog B976. Capsule and cortex of autotransplanted kidney on the 125 th day. Paraffin, hematoxylin and eosin X50.

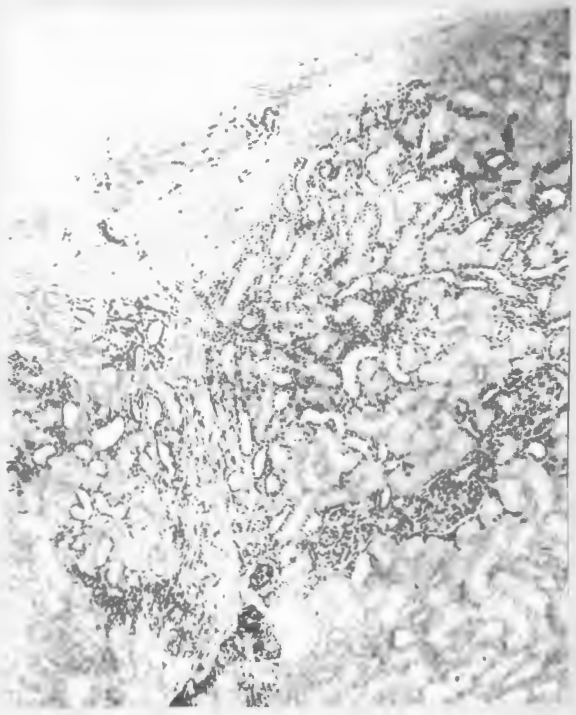

Fig.10. Dog B976. Capsule and cortex of autotransplanted kidney on the 125 th day. Paraffin, hematoxylin and eosin X50.

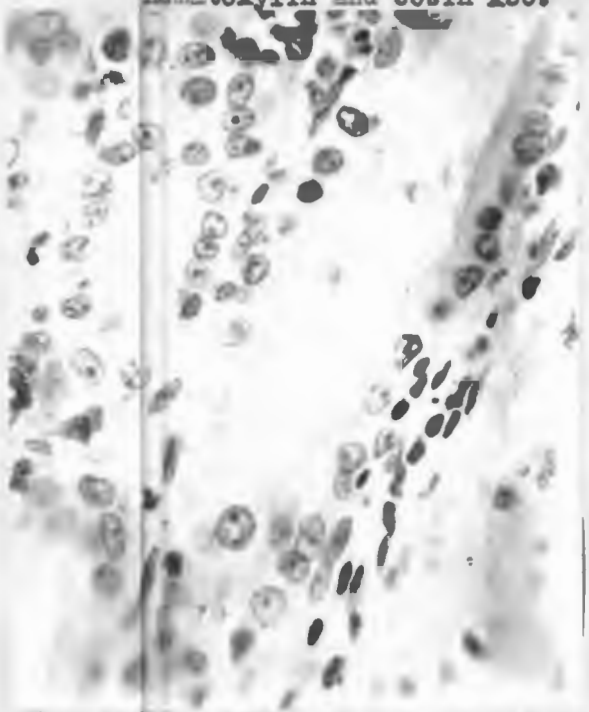

Fig. 11. Dog B976. Cortex of autotransplanted kidney on the 125 th day. Paraffin, hematoxylin and eosin X500.

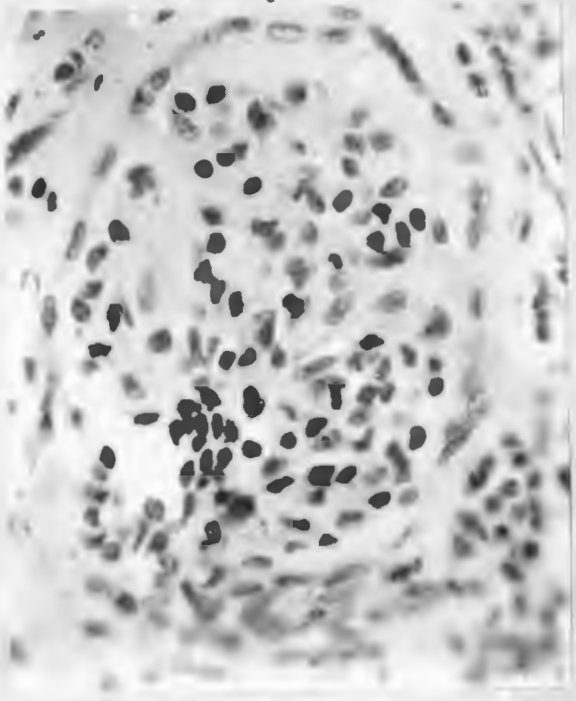

Fig.12. Dog B976 Glomerulus in autotransplanted kidney on the 125 th day. Paraffin, hematoxylin and eosin X500.

Fig. 13. X50

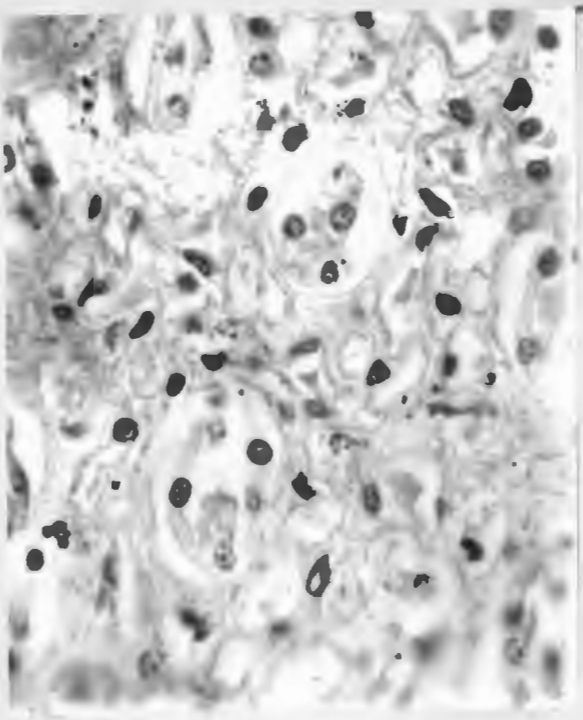

Fig. 14. X500

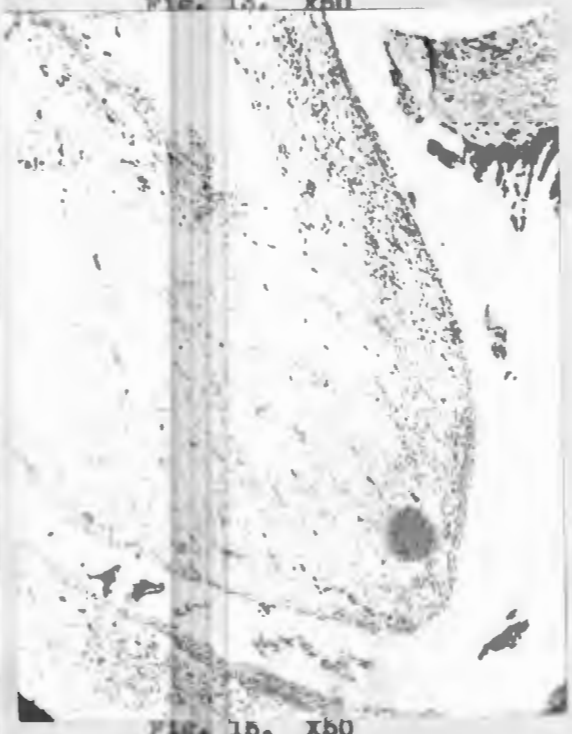

Fig. 15. X50

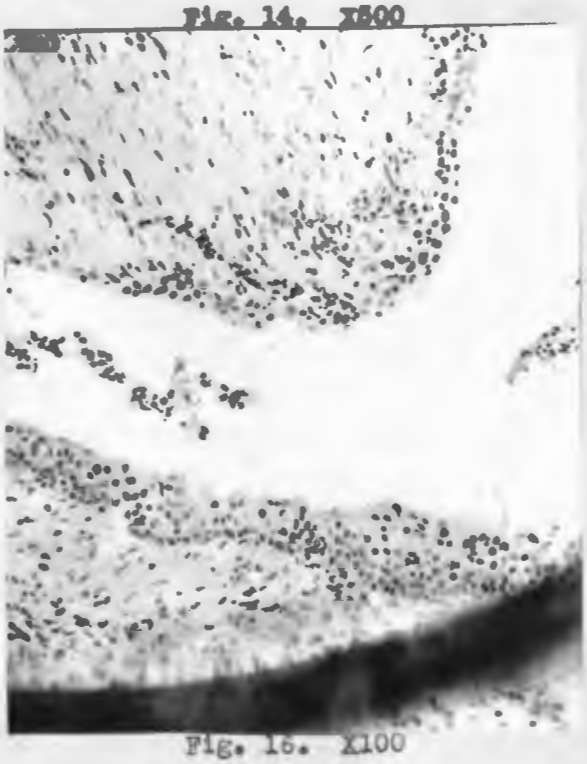

Fig. 16. X100

Figs. 13, 14, 15 and 16. Dog. B976. Sections of autotransplanted kidney in which there was hydronephrosis. Specimen made on the 125 th day. Paraffin, hematoxylin and eosin.

PART II

HOMOTRANSPLANTATION OF THE KIDNEY ALONE AND WITH OTHER GENITO-URINARY ORGANS IN GROUP

The homotransplantations were performed in two series on dogs, goats and monkeys, but mostly on dogs. The first series was done between July 1, 1917, and Nov. 1, 1917. In these cases the kidney alone was transplanted. Some of the details are shown in Table 1. The second series was done between Feb. 1, 1919, and May 1, 1919. The ovary in some cases was transplanted with the kidney. Further details are shown in Table 3. The results of testing the dogs' blood for agglutination are shown in Table 2.

The organ from the donor was placed in a prepared field of operation in the recipient. The blood supply was reestablished through the organ by means of vascular anastomosis. In transplanting the kidney to the neck the ureter was sutured to the skin.

Table 1 continued.

9/20/17	Dog C140 M. Rat terrier 6 kg.	Peritoneum left on kidney	Dog C139 M. Rat terrier 6.2 kg.	Kidney out of circulation 22 minutes	None	Kidney absolved	Seropurulent discharge	Recovery 9/25/17	
9/13/17	Dog C141 F.Fox terrier 6.8 kg.	Anomalous upper artery (sectioned)	Dog.C142 F. Fox terrier 6.3 kg.	Kidney out of circulation 40 minutes	Urine clear changed to bloody 9/17/17	Kidney sloughed out 9/22/17	Necrosis of kidney	Recovery	
10/16/17	Dog C142 F. Fox terrier 6.3 kg.	Vessels cleaned in donor	Dog.C141 F.Mongrd. Fox terrier.6.1kg.	Kidney out of circulation 28 minutes	None	Ureter dried 10/17/17 Kidney removed	Arterial thrombosis	Recovery 10/27/17	
9/19/17	Monkey No.1. Rhesus 2.3kg.	Vessels cleared in donor	Monkey No. 2 Rhesus 1.5 kg.	Arterial anastomosis completed and satisfactory Operation unfinished				Ether fatality	
10/24/17	Dog C159 M.Dachshund 2.8 kg.	Vessels cleared in donor	Dog C160 F.Dachshund 3 kg.	Commoncarotid 3mm. in diameter.Renal transplanted artery 1 mm. in diameter.	None	Ureter dry 9/25/17.Operation Kidney removed	Necrosis of kidney posterior surface.Clot in common carotid	Recovery	Dogs in the same litter
10/26/17	Dog C160 F.Dachshund 3 kg.	Vessels cleared in donor	Dog C162 F.Dachshund 2.3 kg.	Kidney out of cirdulation 29 minutes.Circulation poor.Kidney immersed in 2% sod. citrate in normal saline	None	Kidney removed	Arterial thrombosis	Recovery Oct.29	Dogs in the same litter
10/30/17	Dog C172 F.Scotch terrier 5.1kg.	Vessels cleared in donor	C 173 M.Fox terrier 4 kg.	Kidney placed in 2% citrate in normal saline Kidney out of circulation 25 min.	Some function up to Nov.6	Kidney removed Nov. 6 for specimen	Vessels patent.Kidney congested	Recovery from operation	On 22nd day died after sulphur mange treatme

SUMMARY OF CASES OF HOMOTRANSPLANTATION IN THE FIRST SERIES

Table 1.

Date of operation	Donor's description	Technic of nephrectomy	Recipient's description	Transplantation operative technic	Function of transplanted kidney	Fate of transplanted kidney	Pathologic findings in transplanted kidney	Operative results Recipient	Remarks.
7/6/17	Dog C40 M.Mongrel terrier 8.8 kg.	Incision, subcostal, costovertebral. Transperitoneal. The vein was clamped first.	Dog C38 F. Curr 8 kg.	Total time 1hr. 32 min. Circulation interrupted 28 min. Kidney in liquid petroleum. No saline sol. Kidney held by suture of muscle	7/6/17 urine nearly clear 7/7/17 urine squirted 6" (1 day)	7/8/17 rupture of vein in swallowing meat. Ureter dark, kidney enlarged. 7/9/18 ureter bled 7/10/18 extirpated kidney	Cortex pink. Medulla maroon. Cortical surface necrotic. Traumatic venous rupture	Recovery	Necropsy 8/17/17 Fatal dog bite. Severe hemorrhage; pneumonia.
7/13/17	Dog C39 F.Mongrel 7.3 kg.	Costovertebral incision. Transperitoneal usual technic	Dog C52 F.Mongrel terrier 7 kg.	Thyroidectomy. Carotid artery freed 2 in. Ext. Jug. freed nearly 2 in. 1% soda in pelvis of transplant. oil used.	7/14/17 ½cc. in 20min. Alk. alb. casts. 7/15/17 leuks. 7/17/17 clear alk. but blad. ur. acid	7/13/17 Ureter bled. 7/17/17 abscess neck. 7/18/17 Autolysis. Removal.	Nearly liquefied. Suppuration was present	Recovery	Necropsy 8/15/17 Gangrene with suppuration rt. fore leg Dog bites in neck.
7/20/17	Dog C60 M.Mongrel	Kidney removed from this dead dog used. 1% boiled. Sod. bicarb. into pelvis	Dog C61 F.Mongrel 7.8kg.	Vein quite short. Less oil used. Kidney dried somewhat. Catgut sutures to hold kidney down	7/20/17 urine flow after exertion. 7/21/17 no urine	7/21/17 Ureter hard and dark. Exploration vessels intact Blood not flowing. Kidney removed.	Venous stasis, specimen, photos. of slide x50; x500.	Recovery	Serum of C61 agglutinated C 60 cells.
7/25/17	Dog C63 F.Terrier 7.7 kg.	Vessels cleared in donor	Dog C41 F. terrier 10.3kg.	58 min. from clamp renal, till off but 30 sec. flow after 1st 18 min.	Urine clear on 5th day contained pus cells on 8th day	Kidney pushed out through wound Aug. 13. partially disintegrated	Pale, flaby much degenerated	Recovered	

Table 1 continued.

9/8/17	Dog C134 M.terrier 9 kg.	Vessels cleared in donor	Dog C63 F. terrier 8.3 kg.	Circulation off 1 hr. 1min. Received an indeterminate amount of blood from donor by tube transfusion	1 day blood present with blood casts	Sept.10 sloughing.Kidney removed, both vessels thrombosed	Necrotic seropurulent material	Recovery	
8/28/17	Dog C121 M. Fox terrier 5.7 kg.	Vessels cleared in donor	Dog C122 F. Fox terrier 5 kg.	Circulation off 35 minutes	No secretion	Suppuration disintegration	Suppuration	Recovery	Cells of C121 agglutinated by serum of C122
9/18/17	Dog C122 F. Fox terrier 5 kg.	Vessels cleared in donor	Dog C121 M. Fox terrier 5.7 kg.	Circulation out of kidney 31 min. Ureter bled satisfactorily	None	Necrotic kidney removed	9/20/17 Kidney necrotic Vein thrombosed below anastomosis	Recovery 9/25/17	Serum C122 agglutinated cells of C121
9/4/17	Goat 60	Vessels cleared in donor	Goat 70 36.2kg.	Clots in artery during operation	None	White ureter Gangrene removal	Arterial thrombosis Vein empty	Recovery 9/15/17	
9/22/17	Goat 70 36.2kg.	Vessels cleared in donor	Goat 71	Kidney out of circulation 35 minutes.	None	Ureter dried kidney not felt	Arterial thrombosis Vein empty infection	Goat lost 9/26/17	Kidney should have been removed when it failed and saved goat.
9/11/17	Dog C137 M.Mongrel *fox hound* 15.3 kg.	Vessels cleared in donor	DogC138 M. Fox terrier 9.3 kg.	Kidney out of circulation 41 minutes	None	Ureter dark dry.Kidney enlarged	Extensive thrombosis Separation at each anastomosis Hemorrhage	Dog lost 9/14/17	Kidney should have been removed and saved dog
9/12/17	Dog C139 M. Rat terrir 6.2 kg.	Vessels cleared in donor	Dog C140 M. Rat terrier 6.2 kg.	Kidney out of circulation for 36 min. Oil used No saline used on vessels or kidney today	Good function for 1 day 9/15/17 Many blood cells.9/16/17 purulent	9/16/17 firm. Ureter dark dry.	Seropurulent Sloughing from wound	Recovery	

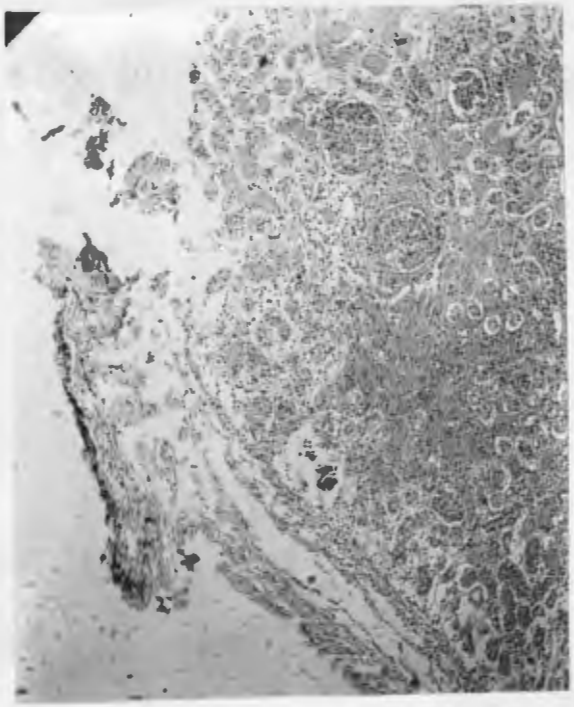

Fig. 17. Dog C61 (Table 1) Transplanted kidney.
Fixed specimen, frozen section, hematoxylin and eosin X50.

Fig. 18. Dog C173 (Table 1). Homotransplanted kidney removed on the first day of urinary cessation. The kidney was much congested and enlarged. The vessels were patent (8 th day).

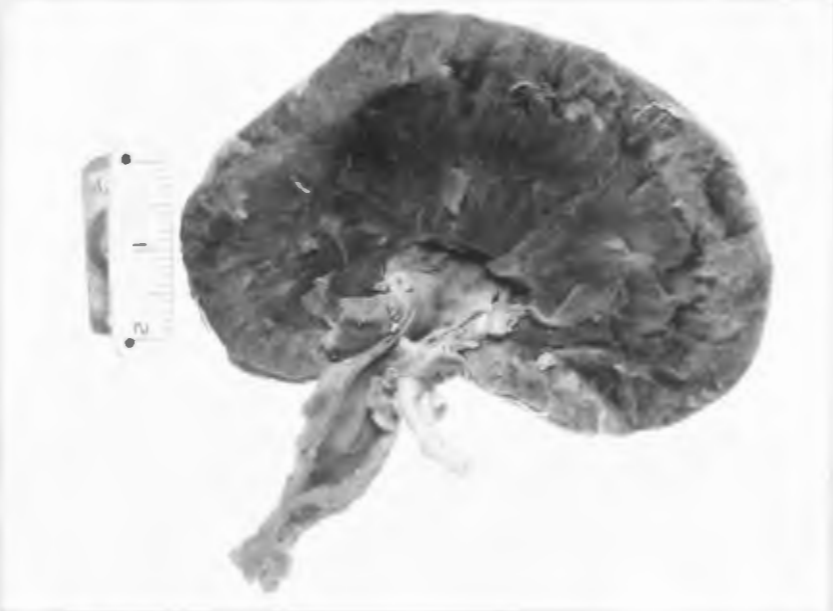

Fig. 19. Dog C173 (Table 1). Homotransplanted kidney. The ureter is shown laid open. Excretion was present until the 8th day. The vessels were patent but the vein was diminished in size.

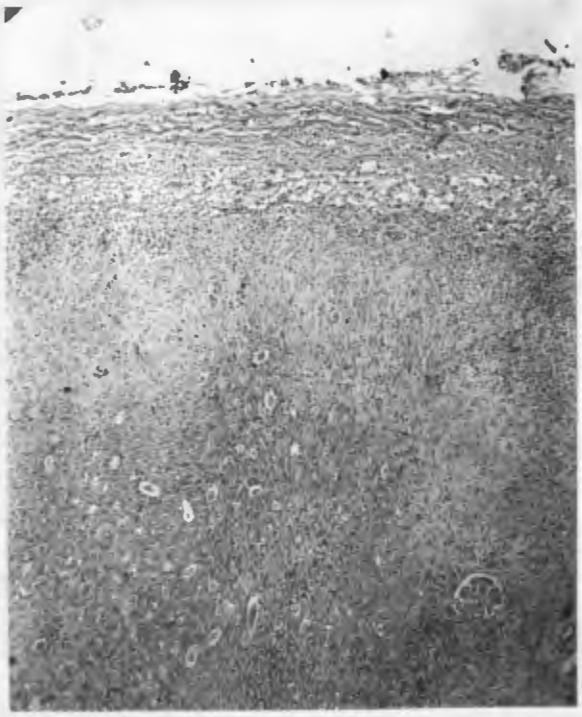

Fig. 20. Dog C173 (Table 1). Homotransplanted kidney showing the condition on the first day of cessation of excretion (8 th day after operation) Paraffin, hematoxylin and eosin X50.

Table 2.

Agglutination tests for kidney transplants

Date blood taken	Hour taken	Time examined	Time observed (min.)	Serum of dog No.	Cells of dog No.	Reaction
Sept. 6	P. M.	Sept. 7 A.M.	10	C121	C122	negative
Sept. 6	P. M.	Sept. 7 A.M.	10	C122	C121	positive
Sept. 7	11:30 A.M.	5:00 P.M.	10	C63	C122	negative
Sept. 7	11:30 A.M.	5:00 P.M.	10	C63	C121	negative
Sept. 7	11:30 A.M.	5:00 P.M.	10	C121	C63	negative
Sept. 7	11:30 A.M.	5:00 P.M.	10	C122	C63	negative
Sept. 7	P.M.	Sept. 8 A.M.	15	C63	C134	negative
Sept. 7	P.M.	Sept. 8 A.M.	15	C134	C63	negative
Sept. 11	10:30 A.M.	11:30 A.M.	12	C137	C138	negative
Sept. 11	10:30 A.M.	11:30 A.M.	12	C138	C137	negative
Sept. 12	11:00 A.M.	11:30 A.M.	15	C140	C139	negative
Sept.12	11:00 A.M.	11:30 A.M.	16	C139	C140	negative
Sept.13	11:30 A.M.	12:00 M.	10	C141	C142	negative
Sept. 13	11:30 A.M.	12:00 M.	10	C142	C141	negative
Sept. 17	10:30 A.M.	2:00 P.M.	15	C41	C121	negative
Sept. 17	10:30 A.M.	2:00 P.M.	15	C41	C122	negative
Sept. 17	10:30 A.M.	2:00 P.M.	15	C121	C41	negative
Sept. 17	10:30 A.M.	2:00 P.M.	15	C122	C41	negative
Sept. 17	10:30 A.M.	2:00 P.M.	15	C121	C122	negative
Sept. 17	10:30 A.M.	2:00 P.M.	3	C122	C121	positive
Sept. 22	12:00 M.	Sept.24 A.M.	15	Goat 70	Goat 71	negative
Sept. 22	12:00 M.	Sept.24 A.M.	15	Goat 71	Goat 70	negative
Oct. 24	5:00 P.M.	Oct. 25 A.M.	10	C159	C160	negative
Oct. 24	5:00 P.M.	Oct. 25 A.M.	10	C160	C159	negative
July 21				C60	C61	positive
July 21				C61	C60	negative

SUMMARY OF CASES OF HOMOTRANSPLANTATION IN THE SECOND SERIES

Table 3.

Date of operation	Donor's description	Remarks on removal of organs from donor	Recipient's description	Particular operative procedures which might have bearing on the cases.	Function of transplants	Fate of transplants	Pathologic findings in transplanted organs	Operative results	Remarks
2/7/19	DogD6, M. Fox terrier 9 kg.	Lt.nephrectomy. Vessels cleaned in donor	DogD7, M. Mongrel Fox terrier 7.1kg.	Temporary jugular constriction from fascia below anastomosis. Engorgement till loosened. Kidney out of circulation 34 minutes.	Phthalein returned quickly on second day	Necrosis	Specimen putrifactive	Fatality	To save dog necrotic kidney should have been removed earlier
2/10/19	DogD8, F. Fox terrier 6 kg.	Lt.nephrectomy. Renal vessels cleaned in donor	DogD9, F. Fox terrier 6.5 kg.	External carotid larger than renal. Leaks restitched. Kidney out of circulation 48 minutes.	None	Removed from neck 2/11/19	Arterial thrombosis. Suppuration	Recovery Sent to farm.	
2/11/19	DogD11, F. Shepherd collie 3.9 kg.	Lt.kidney. Ovary and tube transplanted with collateral ovarian circulation	DogD12, F. Shepherd collie 3.2 kg.	32 stitches taken in vein with constriction; 34 in artery. Renal artery 2mm. carotid 3 mm. diameter. Out of circulation 31 minutes	No excretion	Removed from neck 2/12/19	Arterial thrombosis. Peripelvic hematoma	Recovery. Used for another experiment	Puppy same litter.
2/13/19	DogD20, F. Shepherd collie 3.1 kg.	Removal in a group. Lt.kidney, ovary and tube with ovarian vein near vena cava	DogD21, F. Shepherd collie 2.9 kg.	Clot in renal jugular vein was manipulated out into circulation. Temporary respiratory paralysis. Organs out of circulation 42 minutes.	Normal. Phthalein returned in 2 min. 40 sec. 26th day.	Removed at necropsy 3/11/19	Kidney and ovary showed normal parenchyma grossly and microscopically	Fatality from distemper. Ulcer with intussusception	Puppy same litter Bronchopneumonia.
2/18/19	DogD28, M. Mongrel coach 15.6 kg.	Removal in a group. Lt.kidney, testis, cord and cremaster with spermatic vein.	DogD29, F. Mongrel coach 11.5kg.	Dakin solution poured into wound. Recognized field contamination in neck. Organs out of circulation 42 minutes	Good till 2/21/19	Testis sloughed out. Kidney removed from neck 2/21/19.	Renal venous stasis 2/21/19	Recovery sent te farm	Wound infection.

Table 3 continued.

2/19/19	Dog D12, F. Shepherd collie 2.9 kg.	Removal in a group. Lt. kidney, ovary tube and adrenal also with ovarian vein (to renal)	DogD11, F. Shepherd collie 3.5 kg.	Renal artery diam. 1.25 mm. External carotid 2.6 mm. Renal vein (filled) 2.6 mm. Organs out of circulation 31 minutes	No excretion	Removed from neck 2/20/11	External carotid thrombosis.	Recovery used for another experiment	Puppy same litter.
2/22/19	Monkey #3. F. Rhesus 4.2 kg.	Lt. nephrectomy Dense adhesions around kidney and renal vessels.	Monkey #4 M. Rheesus	Femoral vessels in Hunter's canal used. Difficult because of thin vein wall and excessive perivascular fibrous tissue.	None. Operation not completed satisfactorily.	Removal before wound closure	Too much fibrous tissue around vessels	Recovery	
2/24/19	Dog D32, F. Mongrel terrier 9.3 kg.	Lt. kidney, ovary and tube in group. Bifurcated artery. No definite ovarian vein to renal.	DogD33, M. Mongrel terrier 9 kg.	Kidney and ovary transplanted to neck. Organs out of circulation 28 minutes.	Good while in recipient	Removed in 24hrs. for retransplantation to donor	Culture showed infection	Recovery, sent to farm	
2/25/19	Dog D33, M. Mongrel terrier 9 kg.	Removal for homotransplant of portions of neck vessels with the lt. kidney, tube, ovary from neck.	DogD32, F. Mongrel terrier 9.3 kg.	Kidney and ovary transplanted to neck after being out of dog 24 hrs. (temporarily in another dog) Vessels homotransplanted. Organs out of circulation 25 min.	Pus in urine 2/27/19	Removed 2/28/19	Pyonephrosis ovary hemorrhagic	Recovery, sent to farm	
3/4/19	Dog D40, F. Mongrel terrier 6 kg.	Removal of lt. kidney, tube, ovary in group with ovarian vein	DogD41, M. Mongrel terrier 5.4 kg.	Femoral vessels used. Nephrectomy. Ureteral anastomosis. Iodine used on organs and wound. Organs out of circulation 37 min.	None demonstrated	Removed 3/7/19	Anemia from thrombosis Ovarian vein patent	Recovery, sent to farm	
3/5/19	DogD45, M. Fox terrier 9.3 kg.	Lt. nephrectomy	DogD46, F. Fox terrier 6.4 kg.	Nephrectomy and ureteral anastomosis. Femoral vessels used. Kidney was allowed to be out of circulation 1 hr., 24 minutes.	None demonstrated	Removed 3/7/19	Renal venous stasis arterialstasis secondarily	Recovery sent to farm	Probably venous kinking

Table 3 continued.

3/12/19	DogD59, F. Mongrel 3 kg.	Removal of lt. kidney, ovary, tube, bladder in group. Transference of donor's rt. ureter to skin	DogD60, F. Mongrel 2.9 kg.	Bladder at ureteral opening sutured to skin. Vessels sectioned with scissors. Dakin's sol. in wound. Organs out of circulation 40 minutes.	None	Removal from neck 3/13/19	Venous stasis artery patent	Recovery; sent to farm	Puppy of same litter.
3/14/19	DogD63, F. Mongrel hound 7.5 kg.	Removal of lt. kidney, ovary, tube, ovarian vein bladder, in group. Rt. ureter transposed to urethra in donor.	DogD64, F. Mongrel hound 6.3 kg.	Artery sutured first. Dakin sol. in wound. Bilateral nephrectomy in 3 days. Organs out of circulation 35 min.	Intermittent, hydronephrosis especially after 3/22/19	Bladder removed from neck same night for extravasation.	Infected hydronephrosis. Bladder circulation deficient. Infected hernia	Fatality 3/24/19	Young dog of same litter.
3/21/19	Dog D71, F. Mongrel collie 3 kg.	Removal of lt. kidney, ovary, ovarian vein, tube, in group. Renal artery 1½ mm. diameter	DogD72, F. Mongrel collie 2.5 kg.	Artery sutured first. Jugular vein became a little dried. Venous constriction; 30 arterial sutures; 47 venous. Organs out of circulation 40 min.	None	Removed from neck in 24 hrs.	Renal venous stasis	Recovery used for another experiment	Puppy of same litter.
3/25/19	DogD72, F. Mongrel collie 2.6 kg.	Removal of kidney ovary, tube, ovarian vein. Vein cleaned in donor	DogD81, F. Mongrel collie 2.6 kg.	Vein sutured first. 33 venous sutures, 24 arterial sutures Satisfactory anastomosis. Renal artery 1.5 mm. in diameter when filled. Bilateral nephrectomy at same operation. Organs out of circulation 1 hr. and 1 min.	None	Removed from neck in 24 hrs.	Complete venous stasis	Dog was sacrificed Ether used	Puppy of same litter. Low blood pressure likely.

Fig. 21. Dog D12 (Table 5). Homotransplanted kidney and ovary. Fresh specimen. At operation the vascular pedicle in the donor had been twisted or otherwise obstructed by mistake for perhaps half an hour. The specimen was removed from the neck 27 hours after operation. The ovarian vein and renal vein were patent. The artery was thrombosed. The thrombus may be seen in the photograph. The ovary is shown hemisectioned.

Fig. 22. Dog D32. (Table 3). This kidney was removed from dog D32 and was kept out of the body and in the neck of dog D33 for 24 hours. It was then retransplanted to the neck of dog D32. Blood vessels were homotransplanted from dog D33 to dog D32 with the renal vessels. The dilated ureter is shown. The ureter was filled with water and clamped, for the photograph. Increase of perivascular connective tissue is present.

Fig. 23. Dog D32 (Table 3) Kidney which had been first homotransplanted then 24 hours later retransplanted to the original owner. Segments of artery and vein about 1 cm. long which were homotransplanted with the kidney to dog D32 are shown. Fixed specimen.

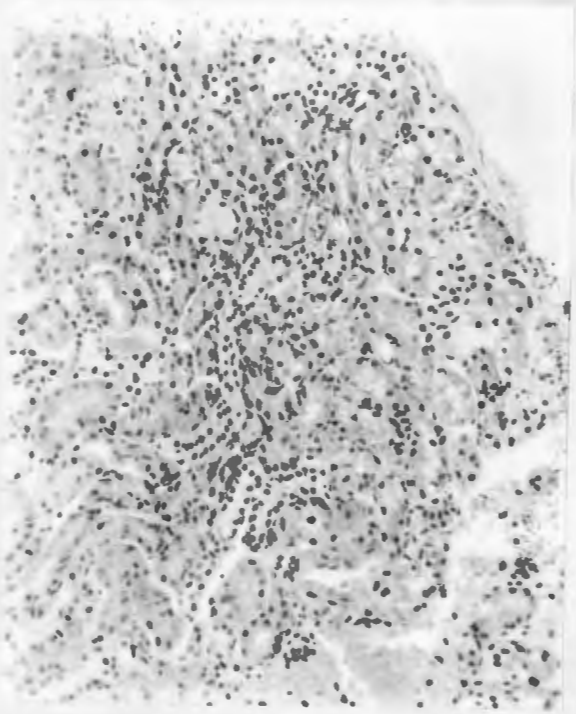

Fig. 24. Dog D32 (Table 3). Kidney cortex immediately after retransplantation to the donor. The kidney had been out of the body and in another dog for 24 hours. Fixed frozen section, hematoxylin and eosin X100.

Fig. 25. Dog D60 (Table 3). Homotransplanted kidney 24 hours after operation showing the picture of venous stasis with hematoma around the renal pelvis and an enlarged and congested ureter.

Fig. 26. Dog D81 (Table 3). Kidney 24 hours after homotransplantation showing the typical picture of venous thrombosis. The ovarian vein and renal artery are empty.

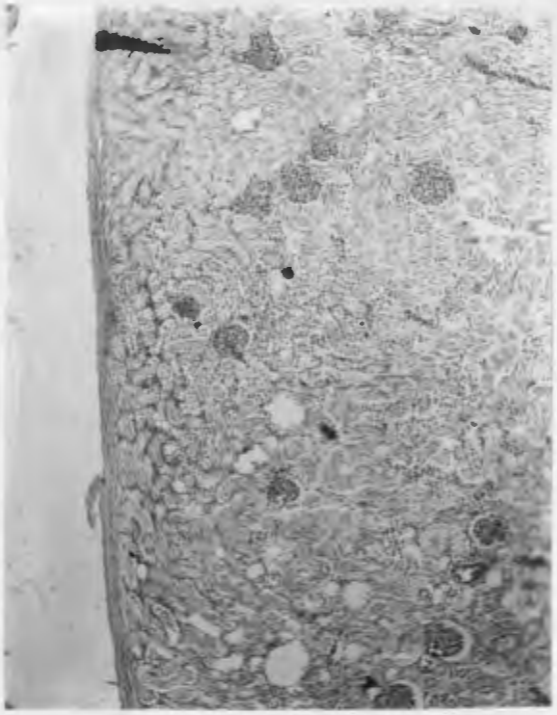

Fig. 27. Dog D61. (Table 5). Homotransplanted kidney 24 hours after operation. The kidney vessels showed venous thrombosis. Fixed specimen, frozen section, hematoxylin and eosin X50.

A case of successful homotransplantation of the kidney and the ovary in a dog

The left kidney and ovary together with their blood supply were transplanted from one puppy to the neck of another of the same litter. Circulation through the organs was continuous with the exception of 42 minutes during which time the organs were simply left out in the air in the field of operation.

An avoidable accident, which almost cost the life of the dog, occurred during this operation. The venous anastomosis was completed first. The temporary clamp on the vein had become removed in some way. This was observed but it was thought that no harm would result. However during the arterial anastomosis the vein had become filled with blood which had clotted. In order to save the experiment the clot which was about two or three centimeters long was pushed along into the general circulation. In a few minutes the dog showed signs of respiratory paralysis. Artificial respiration appeared to be unavailing. The sterile towels were being removed when as a result of persisting in artificial respiration the dog breathed. The breathing returned to normal after about ten minutes of Cheyne-Stokes respiration. Operative conditions were again restored by painting the kidney and wound with 4 per cent iodine in ether and by flushing the wound with Dakin solution. On the evening of the same day, urine flowed from the ureteral orifice and continued to flow in waves as long as the dog lived, in spite of the fact that some of the urine was excreted by its own two kidneys. The function of this kidney was demonstrated from time to time including one test on the twenty-sixth day after operation. On this day phenosulphonephthalein was freely excreted; it appeared in two minutes and forty seconds after its intravenous administration.

On the eighth day, the dog became affected with that virulent disease distemper, which clinically resembles epidemic influenza. The disease became progressively worse, and though periodically improved by persistent treatment eventually the dog was lost.

On the evening of the twenty-sixth day the dog was examined as usual. There was less nasal discharge. The brightness of the dog's appearance suggested an abatement of the respiratory infection. However, as the dog did not walk around and only stood still, further examination was made. The symptoms and signs observed led to the diagnosis of intussusception.

The dog was etherized and placed on the operating table about 10:00 p.m. Intussusception of the lower small intestine was found and reduced in time to prevent any vascular disturbance. An acute inflammatory lesion comprising edema of the intestinal wall and ulceration of the mucous membrane was found at the entering end of the intussuscipiens. The affected area was excised and closed by suture. The wound was closed. The dog died the next day.

Necropsy showed the signs of distemper,particularly a generalized bronchopneumonia. Healing at the site of intestinal repair had hardly begun. The transplanted organs were removed under operative conditions and were tested as to transplantability by anastomosing the renal vessels to the splenic vessels of another dog. Arterial union was satisfactorily made but the venous anastomosis was not accomplished due, in a measure, to the dense adventitia which had developed. The arterial blood which entered the kidney was under considerable pressure because only a portion of it escaped at the site of attempted venous anastomosis. However no damage was observed to result from this influx of blood as was shown by microscopic examination of fixed and frozen sections. The organs were then detached and placed in 10 per cent formalin for further examination.

Dog D21 Extract from the protocol

The dog was operated on Feb. 13, 1919, under ether anesthesia.

10:13 a.m. The incision was made.

10:48 a.m. The renal artery was clamped in donor.

11:30 a.m. The circulation was reestablished. The organs were out of circulation forty-two minutes.

12:02 p.m. The wound was closed.

Feb. 13. Clear excretion from the transplanted kidney.

Feb. 14. Urine yellowish and clear. Occasional squamous cell present.

Feb. 15. Clear urine flowing in waves.

Feb. 16. The spurt of urine extended about 2 mm. from the skin surface.

Feb. 17. Waves of urine 7 to the minute. Some of the stitches were cut.

Feb. 18. Urine flowing in waves. Ureter flush with the skin.

Feb. 19. Epithelial cells in urine. Urine clear.

Feb. 20. Urine clear and flowing in waves. Solitary epithelial cells and a few leukocytes present.

Feb. 21. Urine flowing 10 drops to the minute. Leukocytes again present 15 diameters apart in a drop; epithelial cells present. No albumin. Purulent nasal discharge and cough.

Feb. 22. Dermatitis from excretion of urine. Triple phosphates and leukocytes.

Feb. 23. The urine flows 2 to 5 waves to the minute. Thirty leukocytes to a high power field under a coverglass. Gentian violet allowed to

run under the coverglass stained an organism which was fusiform, encapsulated and in chains of 2 to 5.

Feb. 24. Erythrocytes 50 to a high power field. The caretaker reported later that the dog was out of its cage in the morning which meant that the dog had fallen three or four times its height. Smear from the nose and the ureteral orifice in the skin showed gram positive diplococci occurring in pairs, fours and singly. 9:00 p.m. urine coming in waves, and clear.

Feb. 25. Six waves of urine seen in one minute and three in the next. Phenosulphonephthalein was strongly excreted in two minutes and fifty seconds after intravenous injection of about 1 c.c.

Feb. 26. Nasal discharge and a troublesome cough. Microscopic examination of the urine from the transplanted kidney showed an occasional leukocyte and erythrocyte. Culture from the nasal discharge showed the presence of gram negative chain bacilli, gram positive bacilli occurring end-to-end in pairs.

Feb. 27. A little blood in the stools. Diarrhea. Temperature 39.6 degrees. Urine from the transplanted kidney clear, acid and free from albumin. Microscopic examination showed an occasional leukocyte. Bladder urine clear, acid and microscopically contained several clusters of leukocytes. Vapor treatment for distemper was given several times daily often for over an hour as the dog slept (Fig. 30).

Feb. 28. Urine clear.

Mar. 1. The dog was languid and had anorrhexia; the urine flowing as usual in waves.

Mar. 2. Neck somewhat inflamed from the urine. Urine clear. The dog eats again.

Mar. 3. Urine clear. Twenty-five waves counted in five minutes. Weight 2.7 kg.

Mar. 4. Urine coming in good sized waves.

Mar. 5. Microscopic examination of the urine from the transplanted kidney shows an occasional leukocyte (no casts, crystals, epithelial cells or cellular detritis.)

Mar. 6. Dermatitis of neck.

Mar. 7. Anorrhexia and paroxysms of coughing.

Mar. 8. Bloody diarrhea. Food that was given by making the dog swallow was vomited.

Mar. 9. Weight 2.4 kg. Profuse purulent nasal discharge. The dog licks its fur and wags its tail but still is very weak.

Mar. 10. Urine flowing in good sized waves. In the afternoon about 1.5 c.c. of phenosulphonephthalein was given intravenously. It appeared at the ureteral orifice on the skin in two minutes and forty seconds. A photograph was taken about an hour after the phenosulphonephthalein was given. The renal artery could be felt pulsating. 9:00 p.m. Intussusception was diagnosed. The dog was operated on, the intussusception was reduced and an ulcerated area repaired.

Mar.11. The dog died.

Necropsy: The dog was emaciated. The trachea contained purulent material. The right ventricle of the heart contained a well organized thrombus. An organized thrombus in the left ventricle had some recently clotted blood attached to it. There was no evidence that the thrombi were of pathologic importance at this time. There was a generalized bronchopneumonia. The esophagus was negative. The stomach was negative, containing a little fluid. The repair in the small intestine had hardly agglutinated sufficiently to make it fluid-tight. The liver, gall-bladder, pancreas, kidneys, ovaries and bladder were

negative, except that both kidneys were stained with phenosulphonephthalein.

The transplanted kidney was normal in external appearance, somewhat adherent to the cervical tissues and in its proper location. There was an enlarged lymph node attached more particularly to the peritoneal ovarian ligament. The ovary was normal in appearance. The ovarian vessels were patent and in good condition. The renal aretery was less than 1 mm. in diameter. The artery and vein were in good condition (Figs. 28 to 44).

Fig. 28. Dog D21. The seventh day after a homotransplantation of the left kidney and ovary to the right side of the neck. The dog was in good general condition, and so lively that it was necessary to hold it still. The end of the ureter and changed contour of the neck from the presence of the kidney are shown.

Fig. 29. Dog D21. The fourteenth day after operation. The dog is beginning to show the effects of distemper.

Fig. 30. Dog D21. Feb. 28; receiving inhalations of vapor for severe distemper bronchitis. Later a suitable stall made from boxes was used. In this the dog generally slept during treatments and appeared relieved of a very distressing cough. Ammonium chlorid in doses of 0.1 gm. and other drugs shown were given. The boric acid and container for dusting the powder into the eyes and the nose is shown.

Fig. 31. Dog D21. Twenty-sixth day. Phenosulphonephthalein is being excreted from the ureteral orifice. Immediately around the ureter where the alkali has been washed away by the flow of the urine, the phenosulphonephthalein does not show. In the zone around this area the dye was seen to have its characteristic color which takes black in photographic reproduction. That the dog was very weak from illness may be judged from the photograph. There is a profuse purulent nasal discharge.

Fig. 32. Dog D21. Gross specimen of the transplanted kidney. Fixed in formalin.

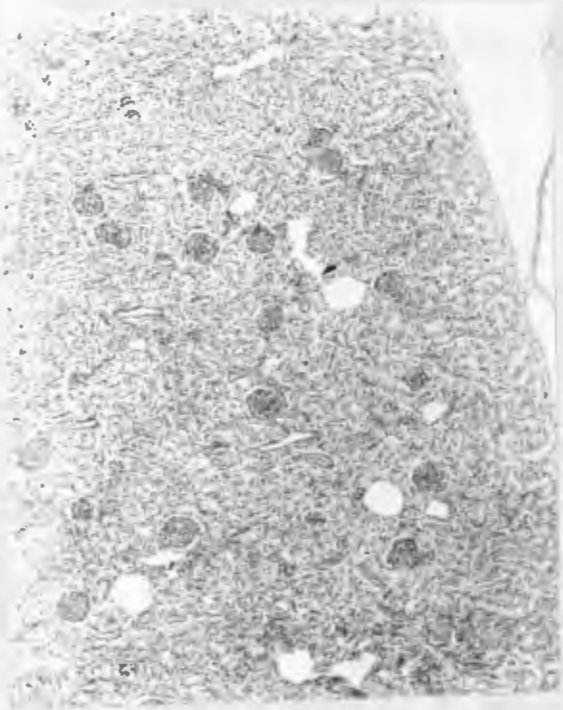

Fig. 33. Dog D21. The dog's own left kidney. Fixed frozen section. Hematoxylin and eosin X50.

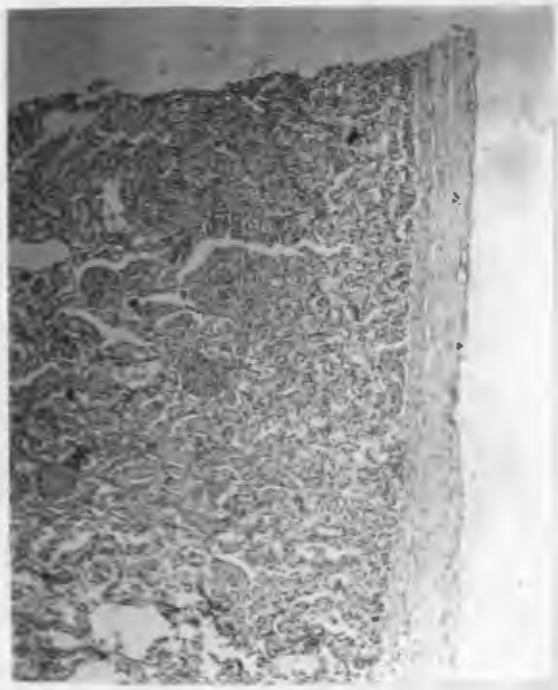

Fig. 34. Dog D21. Homotransplanted kidney on the 27 th day. Fixed frozen section. Hematoxylin and eosin X50.

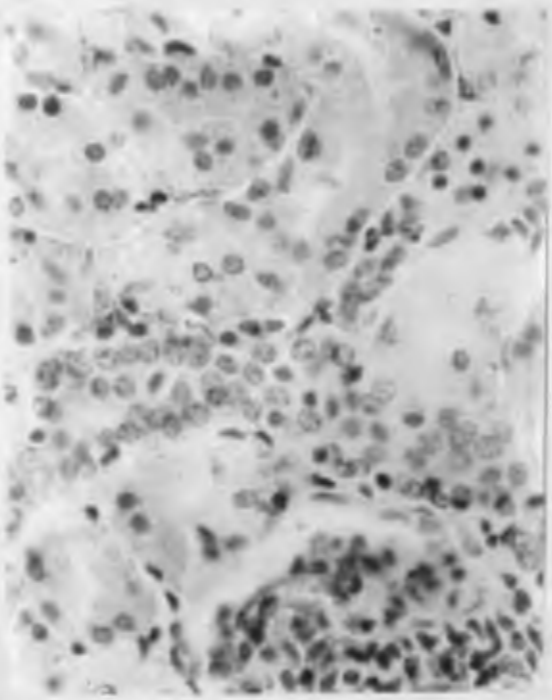

Fig. 35. D21. The dog's own left kidney. Fixed specimen frozen sections. Hematoxylin and eosin X500

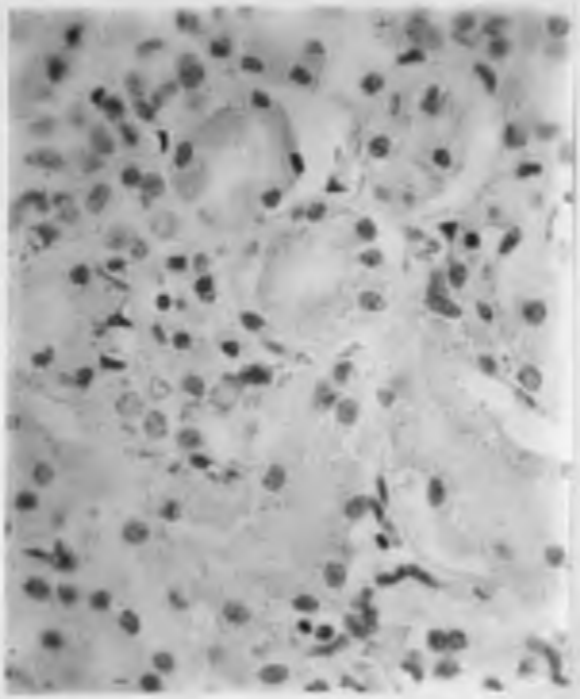

Fig. 36. The transplanted kidney.

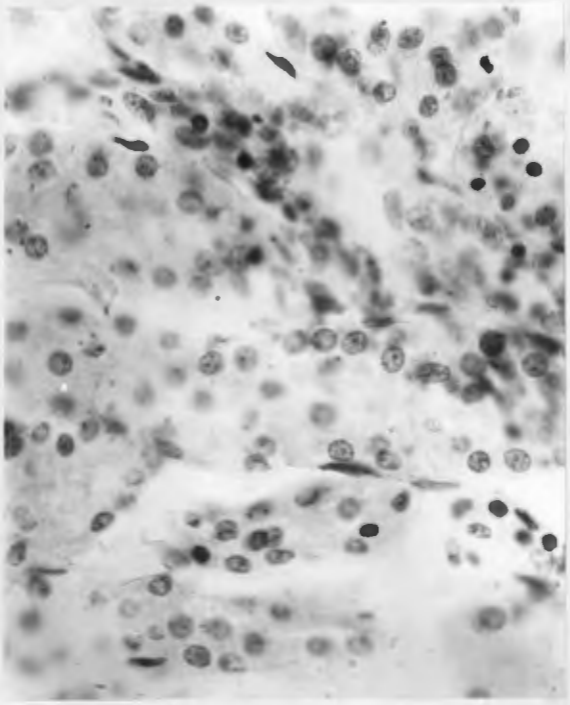

Fig. 37. Dog D21. Transplanted kidney. Fixed frozen section. Hematoxylin and eosin X500.

Fig. 38. Dog D21. Transplanted kidney showing a portion of the kidney which was congested without extravasation. Fixed specimen, frozen section, hematoxylin and eosin X50.

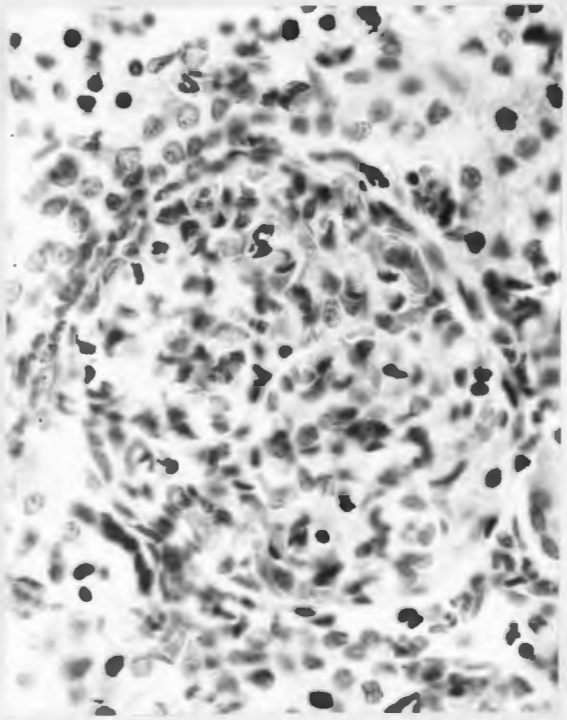

Fig. 39. Dog D21. Transplanted kidney. Congested glomerulus without extravasation. Fixed specimen, frozen section, hematoxylin and eosin X500.

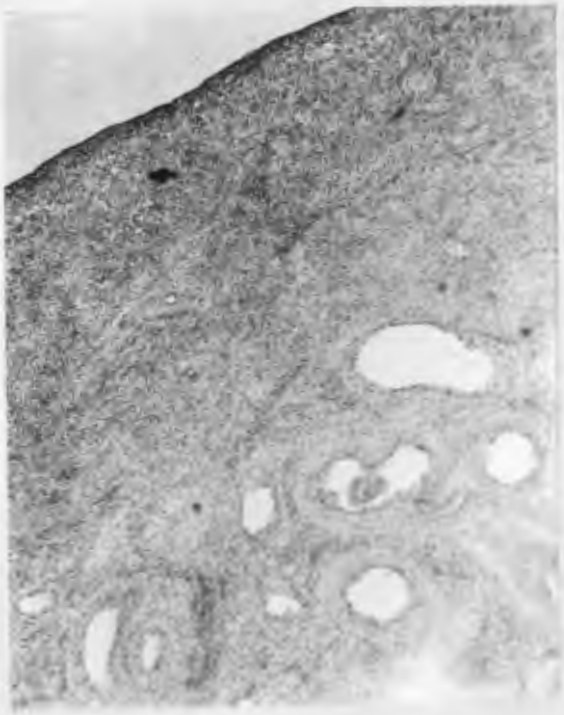

Fig. 40. Dog D21. The dog's own left ovary. Fixed frozen section. Hematoxylin and eosin X50.

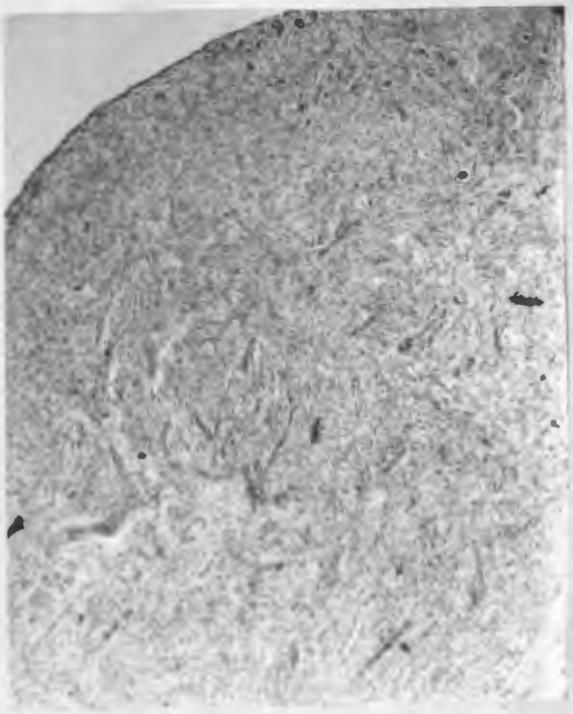

Fig. 41. Dog D21. Transplanted ovary. Fixed frozen section. Hematoxylin and eosin X50.

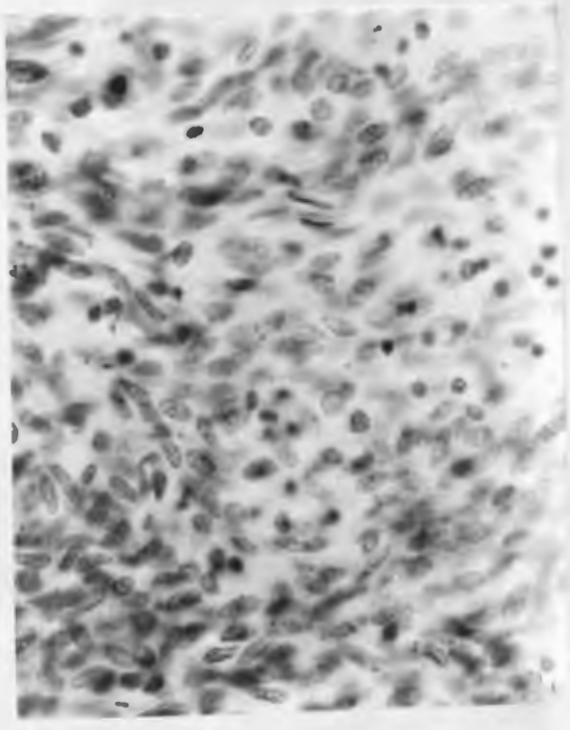

Fig. 42. Dog D21. The dog's own left ovary. Fixed frozen section. Hematoxylin and eosin X500.

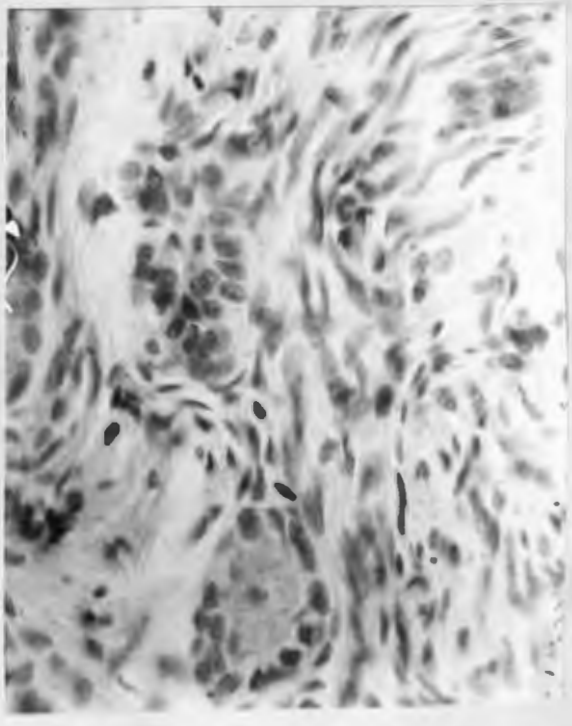

Fig. 43. Dog D21. Transplanted ovary. Fixed frozen section. Hematoxylin and eosin X500.

Dog D21.
Fig. 44./ Distal end of ureter sectioned at its site of union with the skin. Fixed frozen section. Hematoxylin and eosin X50.

The homotransplantation of the kidney, ovary with a portion of the fallopian tube, ovarian vein, ureter, and the entire bladder, with bilateral nephrectomy seventy-two hours later.

The dogs were of the same litter

Dog D64. The group of organs to be transplanted was isolated leaving only vascular connection. In the recipient the neck vessels were isolated, temporarily clamped, sectioned, freed from adventitia, and moistened with saline solution and oil. Six stay sutures were then placed. The organs were removed from the donor and transplanted into the prepared field of operation. The bladder wall was scarified in order to keep it from becoming congested with venous blood. An orifice was made in the skin for the urethral opening of the bladder. The edges of the skin orifice were brought together to form a dermal appendage which was elevated above the surface of the skin (Fig. 45). The wound was closed.

The same evening the bladder was catheterized because of acute retention of urine. Later in the evening an emergency operation was done to remove the bladder because of extravasation of urine. The wound was cleaned and closed. The ureter was fastened into a new opening in the skin. The anastomosed vessels were normal; some adhesions to surrounding structures had begun.

The dog recovered satisfactorily fron this operation and in seventy-two hours underwent a bilateral nephrectomy. The abdominal wall exclusive of the skin was closed by a single strand of plain catgut. This proved to be inadequate, since in a few days the dog acquired an infected omental

Fig. 45. Dog D64. Operative field showing the transplanted kidney, ovary, ovarian vein, collateral vessel in the renal peritoneum, ureter, and bladder. The renal vessels were anastomosed to the neck vessels. On the left is shown the construction of a dermal eminence for the bladder orifice. On the right is shown some of the steps in the vascular anastomosis by which these organs were transplanted. In this case it was more convenient to unite the artery first. Precaution was taken to keep the vein moist while the artery was being sutured.

hernia. There was sufficient function in the transplanted kidney to keep the animal alive (Fig.46). However there was intermittent hydronephrosis which was partially relieved several times by slitting the ureteral orifice.

On the tenth day an operation was performed for the cure of an infected hernia and the relief of a low grade intestinal obstruction. An internal hernia was reduced and a constricting mass of omentum was severed. The abdominal hernia was repaired. However the infection could not be brought under control. The dog died the next morning.

Necropsy showed peritonitis. The transplanted organs were well adhered to the surrounding structures in the neck. The anastomoses were patent. There was a slight constriction at the venous site of anastomosis. The kidney was nearly three times normal in size and in weight. The pelvis contained several cubic centimeters of seropurulent material. The ureter was kinked in acute angles at three places. Cut muscle fibers had tightly adhered to the renal vein.

Microscopically the kidney showed areas of leukocytic infiltration, areas of congestion and areas of normal appearing parenchyma. Some areas showed beginning degeneration. The renal capsule was in good condition. Erythrocytes in one of the congested vessels were discrete and crenated.

There was some congestion in the ovary. The ovarian parenchymal cells appeared normal.

Fig. 46. Dog D64. On the ninth day after the homotransplantation. The dog's own left and right kidneys which were removed seventy-two hours after the first operation are shown lying on the floor. The neck kidney is much enlarged.

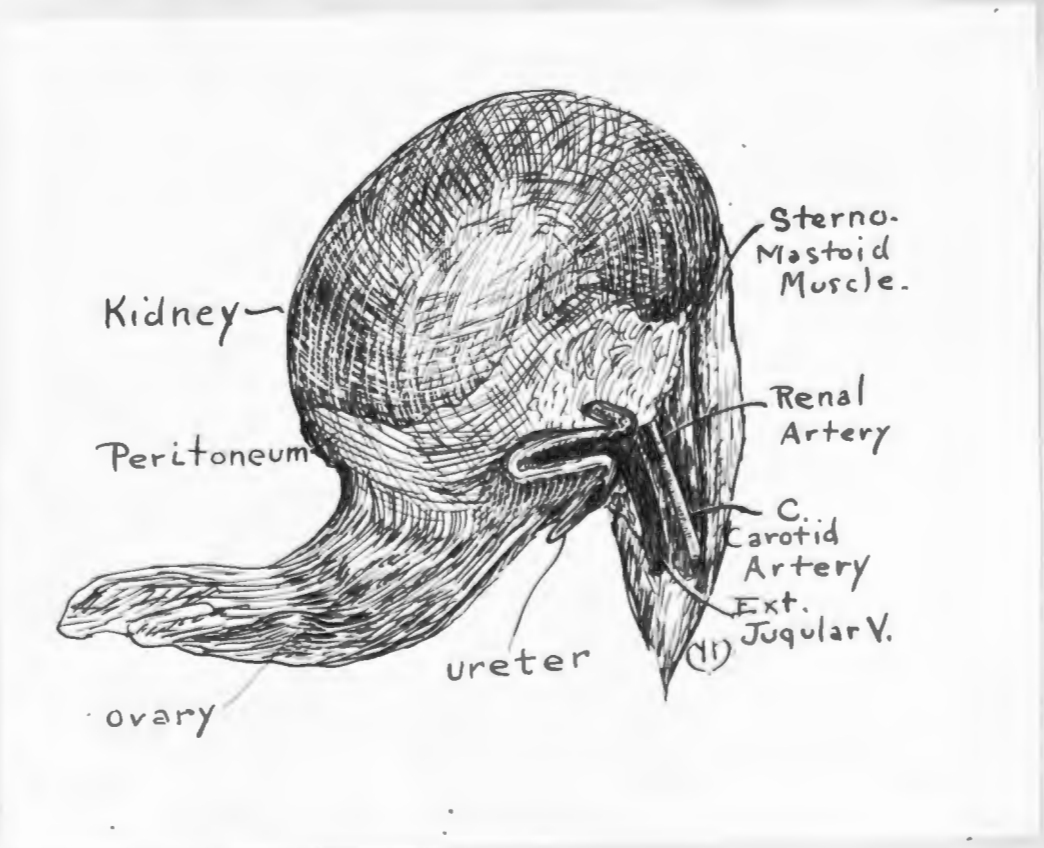

Fig. 47. Dog D64. Specimen of homotransplanted kidney and ovary delivered from the wound the tenth day. Weight of kidney 82 grams. Weight of dog's own kidney 27 grams. There was a deposit of tissue about the site of venous anastomosis in the wall which effected a diminution in the size of the lumen. Both vessels were patent. The arterial anastomosis was satisfactory. The ureter was kinked in three places and showed where the stricture of the meatus had been slit open on the previous day.

Fig. 48. Dog D60 (Table 3). Transplantation of kidney, bladder and ovary, with a portion of the tube. Bulb syringe fitted with an irregating vein dilator. The syringe should be held between two fingers and compressed with the thumb to send the solution into the vein. When the vein is thus opened the dilator will slip in. Release of the pressure will then cause thin vein walls to fit snugly around the bulbous glass end. This method is used for inserting the second and third stay sutures when the veins are very thin walled as in dogs weighing about three kilograms each.

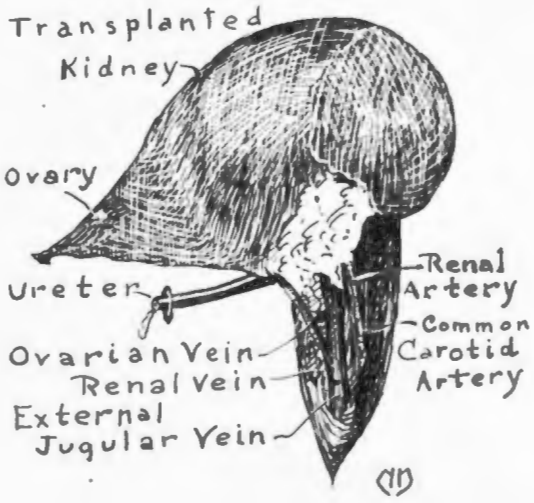

Fig. 49. Dog D72 (Table 3). Appearance of the transplanted organs before placing them in the wound. There were numerous collateral arteries and veins running between the ovary and the renal peritoneum. The ovarian vein is shown.

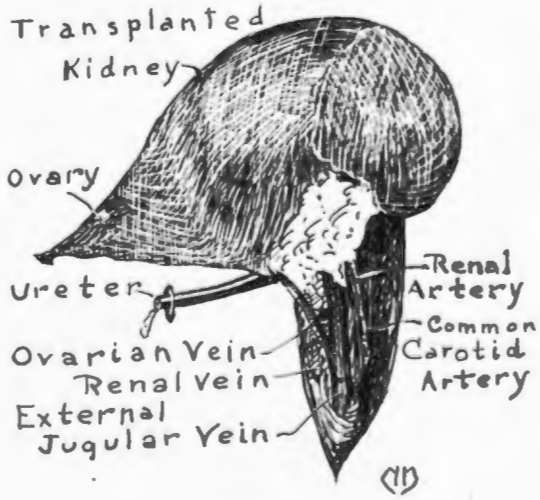

Fig. 50. Dog D81 (Table 3). The kidney was 4.3 cm. in length. The diameter of the renal artery when distended with blood after the anastomosis was completed was 1.5 mm. The drawing is approximately actual size.

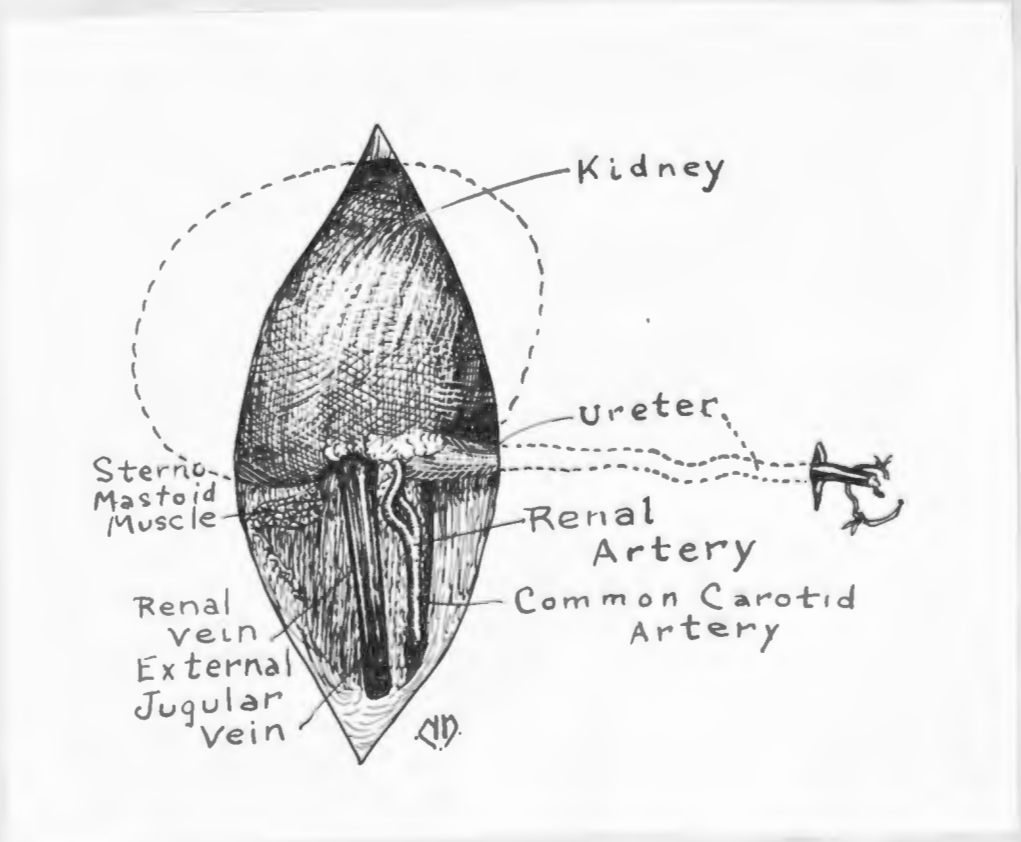

Fig. 51. Dog D88. A case of homotransplantation in Belgian police dogs of the same litter. In this case the upper segment of the cut sternomastoid muscle was loosely sewed to the superficial fascia to support the upper pole of the kidney to prevent vein kinking. On the fourth day there was rupture of the artery at the site of the anastomosis, and arterial hemorrhage resulted. The ureter was pulled into the wound. The vein was patent. It is believed that the damage was done by the shifting of the position of the kidney.

PREOPERATIVE PROCEDURES

Choice of dogs.- Full grown fox terriers were found the most convenient for this work. Dogs weighing more than three kilograms each are preferable.

Preparation.- The dogs are shaved the day before operation. They are fasted during the night. Water is given freely. The special instruments needed for this operation are: Iridectomy knife and scissors. Halsted forceps, Crile clamp, the writer's new design rubber covered clamps for temporary hemostasis, and new design dilating bulb-syringe, light smooth tissue forceps, No.12 and 16 needles, 4 pairs of curved forceps, calipers for measuring vessels and kidney, aneurism needle, medicine dropper for oil, and two intratracheal etherising sets.

Preparation of needles.- The No.16 needles are shortened by simply breaking them off to a length of about one centimeter. They are then ground on an India oil stone. Care must be taken to make a hemihyperboloidal or hemiellipsoidal pointed end on the needle, which is accomplished by holding the needle first at right angles to the stone then gradually reducing the angle of inclination while the stone slowly revolves. The pointed end should be inspected with the low power of the microscope or a jewlers lens.

Sutures.- Raw two-fiber skein silk makes the best suture material. The threaded and knotted sutures should be about 25 cm. long. They are wrapped on small squares of cardboard and thus sterilized in an evaporating dish in oil over a wide gas flame. When boiling begins the cards float. When they sink the gas may be turned off. The silk fibers will stand boiling in water.

Tables.- Two operating tables are used. They are placed about a meter apart at the head forming an acute angle.

Assistants.- Two surgical assistants are desirable. Otherwise the donor has to be kept under the anesthetic longer than necessary.

Disinfection.- The solutions used in this laboratory are benzine and also 4 per cent iodine in ether. A second coat of iodine is applied to the wound after the incision is made.

STANDARD OPERATIVE TECHNIC OF ORGAN TRANSPLANTATION

The operative procedures are divided into seven stages:

Stage 1. The exposure of the organs in the donor.

Stage 2. The incision in the recipient and the preparation of the vessels for attachment of the transplant.

Stage 3. The removal of the organ from the donor.

Stage 4. The transplantation of the organ.

Stage 5. The disposition of the organ.

Stage 6. The closure of the wound.

Stage 7. The application of the dressing.

The technic as applied to the homotransplantation of the kidney to the neck in the dog

1. The left kidney is exposed through an incision which substantially bisects the costovertebral angle. The vessels of the kidney are exposed to make sure that it has no anomalous blood vessel. The ureter is sectioned below the junction of its middle and lower third. The nerves and all adventitious tissues around the kidney are severed and separated from the vessels. The kidney is carefully replaced in its proper position. Care is taken to avoid venous stasis through vascular torsion. The kidney is covered

with a towel moistened with saline solution or with omentum.

2. The landmark for the incision in the neck of the recipient is the right external jugular vein. The incision is made parallel and mesially to this. The vein is quickly exposed and cleaned of adventitious tissue. Care is taken to strip the facia from below upward in order to prevent constriction of the vein. Incision of the superficial layer of the deep fascia is made mesially to the sternomastoid muscle. The deep layer of the deep fascia is incised vertically. The common carotid artery is exposed by means of an aneurism needle and is cleaned. Both vessels are kept constantly moist with normal saline solution and oiled occasionally. A temporary clamp is placed on the artery in the base of the neck. The clamp is so constructed that it will open under a pressure between the/blades of 350 grams, for carotid arteries about 2 to 3 mm. in diameter. For larger arteries a little more compression may be necessary. (I have temporarily clamped the common carotid artery during an exploration of a neck tumor in middle aged men in good health with a clamp which would open under a pressure between the blades of about 400 grams.) end of the

After the blood has been squeezed along the artery, a hemostat is placed on it peripherally. The artery is sectioned with knife-edged scissors in a position so there will be just enough room in which to work between the end of the artery and the base of the neck. If there is any adventitia remaining on the artery it is circumscised. The artery is then surrounded with the first steriae quilt. Three stay sutures are inserted. The first is preferably on a No.16 needle and is inserted posteriorly; the second and third are preferably on a No.12 needle and are inserted laterally. The needles are carefully placed flat on the quilt with a distinctive clamp on each free end. I use one of my own clamps on the first free end of the suture, a rubber-covered Crile clamp on

the second, and a muslin-covered Crile clamp on the third. A pair of Halsted forceps, which are suitable for needle holders, is laid across each suture to aid in keeping it in place. The corner of a gauze sponge moistened with saline solution is placed on the artery.

The vein is clamped with a hemostat peripherally, and with one of my own clamps centrally; this clamp exerts a pressure of 240 grams. The vein is then cut across. The second sterile quilt is placed around the vein beneath the temporary clamp. The venous stay sutures are inserted at a distance from the vein edge equal to about twice the thickness of the vein wall. They are tagged similarly to the arterial sutures which are all concealed by the second quilt. A moist sponge is placed on the vein. If the vein is very thin-walled an irregating dilator is used. The stream of saline solution separates the vein-walls to facilitate the insertion of the dilator. Release of the thumb allows the atmospheric pressure to prevent the vein from slipping off of the dilator.

5. Nephrectomy.- The renal vessels are again exposed. The artery is clamped first; a curved forceps is used. After the vein is clamped both vessels are cut with knife-edged scissors. Free escape of blood is encouraged by gentle pressure. The operation on the donor is finished by an assistant. A gauze-collodion dressing is applied.

4. The renal vessels are washed and from now on are kept moist with saline solution and oil. The forcing of solutions into the kidney is avoided. If there is any adventitia remaining on the renal vessels it should be removed but it can generally be removed before the kidney leaves the donor. The kidney is placed in the field of operation with the renal vessels opposite the neck vessels. The kidney is held in the left hand while the first stitch is taken. The No.16 needle and suture are passed from within outward including all

coats but close to the edge of the vein (Fig.52). This suture is tied with the knot outside. The temporary clamp is replaced on the free end of the suture. Similarly the other two sutures are inserted but this time the clamps are placed on both threads. The needles are removed from these two sutures by cutting the threads of silk close to the clamps. The assistant then holds the rubber-covered Crile clamp in the left hand and in the right hand holds a Halsted forceps. The operator holds the clamp on the posterior thread in the left hand using the index finger when nesessary to depress the renal vein to aid in exposing the vein edge. The operator sutures with his right hand, using Halsted forceps for a needle holder. As soon as the first stitch is completed he relinquishes his hold on the free end of the posterior stay suture and allows this to be held by the weight of the clamp (Fig. 53). He then holds the suture taut each time he pulls it through. The vessel walls are held apart in this position by the action of the weight of the third or muslin-covered Crile clamp. When the end of the first side of the triangle is reached stitching is continued regardless of the fact that there is already is a stitch at this site. The second side of the triangle is then sutured using the posterior stay suture with the weight of the clamp to hold the walls of the vein from sticking together. Similarly the third side of the triangle is completed but this time the suturing thread is tied to the original free end of the posterior suture. All free ends are now cut short. The quilt in view is now removed revealing the field for arterial suture. The arterial suture is completed in a somewhat similar manner (Fig.56). With the thumb and finger on the place of arterial suture the arterial clamp is removed. The clamp on the vein is removed before the blood has time to traverse the kidney. If the stitches are not drawn too tightly there should be momentary oozing along the suture lines. Like any bleeding it can be controlled by suitably applied

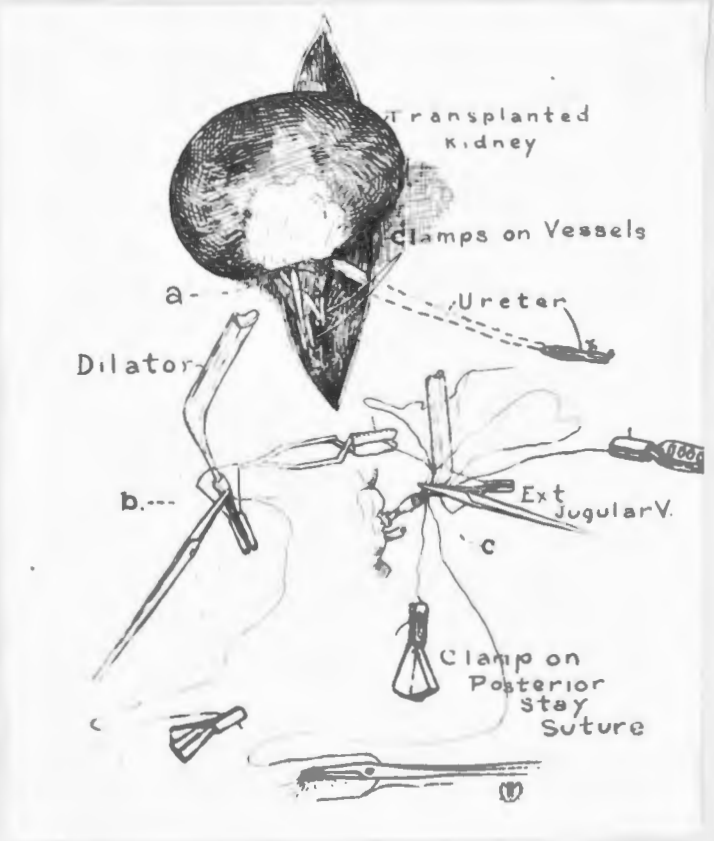

Fig. 52. Dog D105. a. Homotransplantation of the kidney after the completion of the vascular anastomosis. The kidney was placed so low in the neck that there was no danger of venous kinking. In this position the temporary clamps were so placed that they did not interfere with the suturing. b. The posterior stay suture being introduced into the external jugular vein. c. Insertion of the needle for the introduction of the second stay suture into the renal vein. The suture will be tied.

Fig. 53. This drawing shows the use of two black silk sterile quilts. A median incisure extends about two-thirds the length of each quilt. On the upper side of each quilt are two layers of China silk. The under side of the quilt is surfaced with one layer. The quilts should be about thirty centimeters long by twenty-five wide. The vein is about to be anastomosed, beginning with the needle on one end of the posterior stay suture. The renal artery is in view. The common carotid artery with its stay sutures in place and held by a temporary clamp is partially covered with the second sterile quilt.

pressure and ordinarily it readily ceases. This method is nearly always tried in preference to repair sutures which tend to constrict the vessel.

5. A pocket is made for the kidney by bluntly dissecting between the superficial and deep fascias. This pocket should be just sufficiently distant from the base of the neck to keep the vein from becoming kinked (Fig.51). The artery will not kink. By blunt dissection a path for the ureter is made in the direction which it naturally takes. This varies according to whether the kidney is placed with its anterior surface toward the front or the back. The renal vessels vary so in their relation to each other that sometimes one way is better than the other. Through an incision about 1 cm. in length the ureter is pulled beneath the skin and through the superficial fascia by means of a straight forceps (Fig.50). The end of the ureter is cut off to demonstrate that its blood supply is intact. A suture of black linen is placed through the lumen and the wall of the ureter and attached to the skin about 1 cm. from the ureteral incision.

6. The superficial fascia is closed with interrupted stitches of plain catgut No.1. The wound is closed with black linen thread on a straight Hagadorn needle using a 'button-hole' stitch.

7. The wound is painted with the iodine solution. A single layer gauze-collodion dressing is applied. A large gauze dressing wet with Dakin solution is placed on the neck opposite the ureteral orifice. This is held on by a bandage and two wide strips of adhesive plaster which encircle the whole dressing.

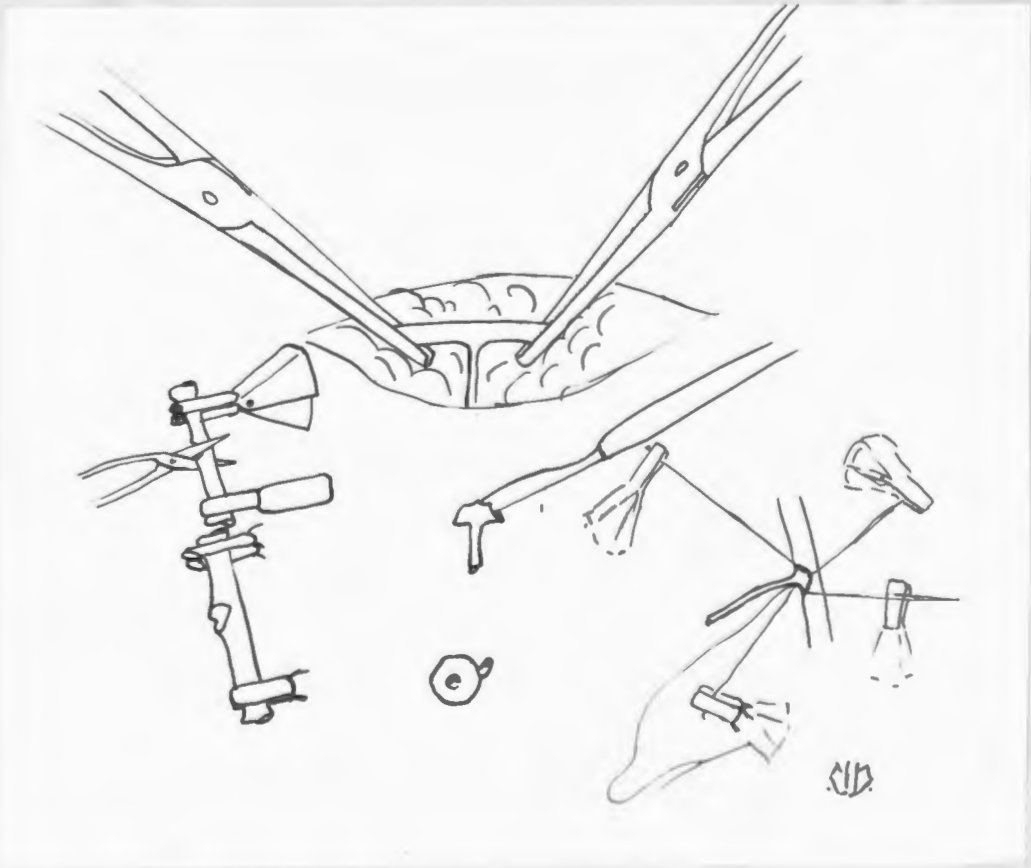

Fig. 54. Method used for homotransplanting organs when the major vessels of the organ are less than a millimeter in diameter, as in the tail of the pancreas, and in transplanting a portion of the sartorious muscle in a small dog.

Stitch interpollation

The matter of the placing of vascular sutures is of such interest and importance that it is discussed separately. By stitch interpollation is meant the proportionate distribution of stitches between the limits of the extremities of the wound. The rule applies in surgery substantially wherever accurate coaptation by suture of nonrigid tissues is necessary, particularly in blood vessel surgery. The object of the method as applied to vascular suture is to attain accurate edge coaptation without constriction.

Rule for stitch interpollation.- The average depth of any two stitches should be greater than the distance between them. By 'depth' is meant the greatest diameter of the mass of tissue included in a stitch (Figs. 55 and 56). By 'stitch' is meant the portion of the suture which circumscribes the tissues outside the path of penetration by the needle through both edges. By the 'distance between two stitches' is meant the distance between them at the points where they cross the line of tissue coaptation.

Rule for stitch interpollation as applied to vascular suture.- In arterial suturing it has been found that the sutures should be inserted a distance from the vessel edge equal to once and a half to twice the thickness of the vessel wall. This determines the depth of the suture. The distance between the sutures is determined by following the rule for stitch interpollation. In venous suturing it has been found practical to insert the needle a distance from the vein edge equal to two to four times the thickness of the vessel wall. The rule for stitch interpollation is then applied to determine the distance between the stitches. If, inadvertantly, one stitch is taken with greater depth than the preceeding all that is necessary to correct the error is simply to apply

Fig. 55. A portion of an artery at the site of anastomosis showing the tendency for the mass of tissue included in a stitch to assume a formation having a circular cross section. Paraffin, hematoxylin and eosin X50.

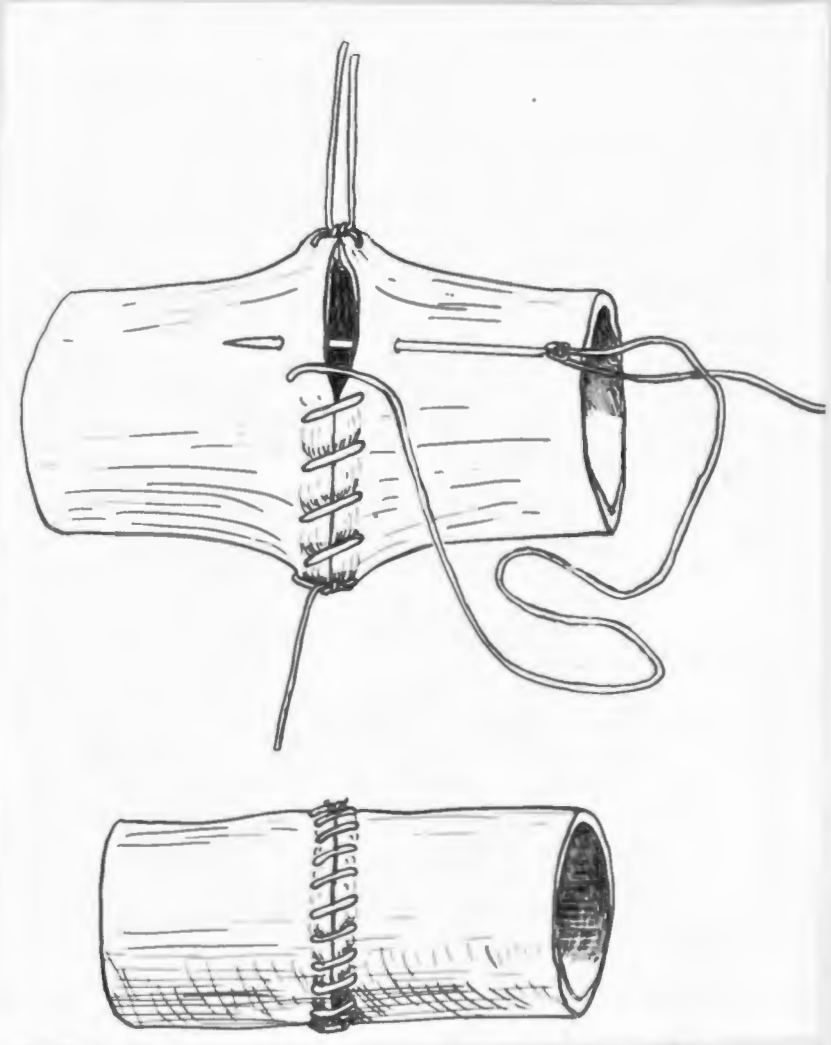

Fig. 56. Diagram showing venous suturing and an artery which has been joined end-to-end, following the rule for stitch interpollation. In the upper drawing is shown the posterior stay suture which has a single free end. The second stay thread comprises two strands. Stitches are taken progressively away from the operator in order to allow him to hold the thread taut with his left hand. The tension on this thread draws the wall on the left side of the anastomosis toward the operator sufficiently to allow him to insert the needle nearly parallel with the axis of the vessel. This facilitates delivery of the needle by the assistant. An enlarged view of the form of knot in the thread is shown. The mass of tissue between opposite stitch holes has a greater average diameter than the mass of tissue between adjacent stitch holes.

the rule and take the next stitch proportionately farther away. If one vessel is much larger than a similar one to be anastomosed to it so also will the vessel wall be thicker, and the stitch will be taken correspondingly deeper in the vessel of greater perimeter. In other words, when similar vessels are of unequal size, the depth of the stitch in the smaller vessel bears the same ratio to the depth of the stitch in the larger vessel that the diameter of the smaller vessel bears to the diameter of the larger vessel. This then reduces the matter of distance between stitches to a rule.

SUMMARY OF OBSERVATIONS AND SUGGESTIONS

In achieving the end results of these experiments certain procedures either failed or did harm, and others were found to be associated with success. It is believed that an enumeration of these suggestive points should be given:

1. Cages and dog rooms should be disinfected with chlorinated lime or other means and thoroughly cleaned before use.

2. Distemper of the eyes and nose are apparently benefited by dusting them with boric acid powder. The dust from the powder is inhaled with inspired air.

3. Boric acid solution as a wet dressing is not quite strong enough to prevent infection from wound contamination.

4. In making experimental transplants in dogs the grouping of the blood of the donor and the recipient is not often of importance.

5. Monkeys require very little ether. The corneal reflex should be retained.

6. Scarifying a bladder, with its entire blood supply coming through the vessels of one ureter is not sufficient to prevent venous stasis.

7. A bifurcated renal artery may be used if after severing the main trunk a portion of it remains.

8. Accuracy should not be sacrificed for speed. Accuracy aids speed by the elimination of waste motion.

9. An apology for technic which is not aseptic should have no cause to exist. Gloves were worn throughout all operations.

10. In a neck dressing the layers of gauze should be intertwined with the bandage. If the wound is low a figure-of-eight should be applied.

11. The use of 2 per cent sodium citrate in the abdomen of the donor causes excessive bleeding.

12. The renal vessels were never temporarily clamped during the transplantation.

13. The blood was always allowed to run out of the renal vessels.

14. When the kidney is first placed in the field of operation in the recipient the artery as well as the vein should be washed out.

15. The vein to be used in the recipient should be cleaned by pushing the surrounding fascia peripherally. If it is pushed centrally it may form a constricting band which will cause constriction of the lumen of the vein and thereby produce venous stasis and thrombosis.

16. In cleaning all vessels small anomalous branches should be watched for.

17. Repairing leaks at the anastomosis should be avoided by perfecting the technic. In small vessels it is very difficult to repair a spurting leak without producing some constriction of the vessel lumen.

18. As a rule the common carotid artery is larger than the renal. It is therefore best to transplant the kidney from the larger of two dogs to the neck of the smaller.

19. An experiment in making the common carotid artery pass through the sternomastoid muscle to reduce blood pressure in the artery showed that this procedure lessened the blood pressure very slightly.

20. If the walls of the end of an artery are stuck together it is presumptive evidence that there still remains some adventitia on the end of the

vessel.

21. If a small renal vein is allowed to retract toward the renal pelvis time will be lost in finding it. When this mistake occurs a trail of venous blood may lead to the vein.

22. A needle 3 mm. long has been used in making an anastomosis in small vessels, such as in the monkey; but if the needle is less than 1 cm. long or more than 1.5 cm. long it adds to the difficulty of the operation.

23. Leaving needles in holders about the field of operation invites breakage of the needles.

24. Excessive use of oil in the renal artery may be followed by the appearance of oil in the urine.

25. After the use of black velvet for a table cover and for the operative field, fibers of black silk were detected microscopically to be entwined in the sutures at the site of anastomosis.

26. The ureter will remain open without splitting it or cutting it slantingly.

27. The path for the ureter should be so well dilated that the lack of excretion cannot be attributed to external pressure on the ureter.

28. Allowing the ureter to come through the main incision invites wound infection.

29. An anastomosed segment of ureter without any blood supply failed to unite.

30. The ureter should always be led away from a transplanted kidney in its natural direction.

31. Kinking of the ureter may be due to a shifting of the position of the kidney.

32. By working with short veins the kidney may occupy a position low in the neck where movements of the head have little effect.

33. When, after the anastomosis is completed, the external jugular vein appears to be "well dilated", look for constriction at the base of the neck. When this is removed the vein should be approximately the same size throughout its course.

34. It should be noted and remembered which pole of the kidney is uppermost, in order to place the ureter so it will run from above downward relative to the kidney.

35. In placing the kidney in the neck it is hazardous to attempt to fasten it by suture to the muscles of the neck. Arterial or venous rupture may ensue.

36. In closing the wound always be certain that the ureter cannot be included in one of the stitches. This does away with one more apprehension about a cause for lack of urinary flow.

37. Means to keep the kidney warm such as an electric pad were found unnecessary.

38. Simultaneous direct venous transfusion from each dog to the other during operation was tried twice. In one case where connections were established through paraffined rubber tubes there was clotting in the tubes.

39. It is best not to use force in holding a dog's head still during a dressing.

40. Provision should be made that when the animal is recovering from the anesthetic that he will not injure the kidney by falling against it.

41. The injection of the ureter with 1 c.c. of 1 per cent bicarbonate of soda did not appear to be beneficial.

42. The routine administration of bicarbonate of soda in the diet did not appear to be beneficial.

43. The renal artery in a dog with only one kidney was clamped with a temporary clamp which exerted a pressure of about 400 grams for thirty-one minutes. The kidney was allowed to become dry on the surface. The dog made an uneventful recovery, gained in weight and remained in good health.

44. In the donor the renal peritoneal ligaments should not be severed below the lower pole of the kidney until the ureter has been located.

45. A transplanted kidney which has obviously failed to functionate should be immediately removed. If left in the animal the results will generally be fatal.

46. Raw silk on No.12 needles is satisfactory for ureteral anastomosis.

47. A cutting pointed end on a blood vessel needle will badly lacerate a delicate vein.

48. Oiling the thread facilitates its passage through the vessel wall.

49. When doubt arises as to the expediency of an operative procedure it should be dealt with in a manner to satisfy the conscience of the operator.

50. In none of the experiments was an ascending infection seen in a kidney if the ureter functionated normally.

CONCLUSIONS

1. Autotransplantation of a dog's left kidney to the neck with right nephrectomy is a satisfactory operation for the study of the function and fate of such a kidney.

2. In dogs of the same litter a homotransplanted kidney and ovary lived. Pathologic examination showed that the organs reacted to severe constitutional infection in a manner similar to that in which the animal's own organs reacted.

3. In mongrel dogs which did not belong to the same litter, the results indicated that there is a critical period between the fifth and the eighth day when cytolysis begins.

4. A homotransplanted kidney during twenty-six days has passed the same functional tests as are required of normal kidneys.

REFERENCES

1. Bernheim, B.M.: Surgery of the vascular system. Phila., Lippincott, 1913, 104 pp.

2. Berst, ... and Enderlen: Über Transplantation von Gefässen und ganzen Organen. Deutsch. Ztschr.f.Chir.,1909, xcix, 54-163.

3. Carrel, A.: La technique opératoire des anastomoses vasculaires et la transplantation des viscères. Lyon méd., 1902, xcviii, 859-864;
The surgery of blood vessels, etc. Johns Hopk. Hosp. Bull., 1907, xviii, 18-28;
Results of the transplantation of blood vessels, organs and limbs. Jour. Am.Med.Assn.,1908, li, 1662-1667;
Doppelte Nephrektomie und Reimplantation einer Niere. Arch.f. klin. Chir., 1909, lxxxviii, 379-411.

4. Decastello, A.v.: Ueber experimentelle Nierentransplantation. Wien. klin. Wchnschr., 1902, xv, 317-318.

5. Dederer, C.: Studies in the transplantation of whole organs. I.Auto-transplantation of the left kidney to the neck with right nephrectomy in the dog. Jour. Am. Med. Assn., 1918, lxx, 6-9.

6. Dörfler, J.: Ueber Arteriennaht. Beitr.z. klin.Chir., 1899, xxv, 781-825.

7. Floresco, N.: Recherches sur la transplantation du rein. Jour. de Physiol. et de Path. Gen., 1905, vii, 47-59.

8. Guthrie, C.C.: Some physiologic aspects of blood vessel surgery. Jour. Am. Med. Assn., 1908, li, 1658-1662;
The effect on the kidneys of temporary anemia alone and accompanied by perfusion. Arch. Int. Med., 1910, v, 232-245;
Blood-vessel surgery and its applications. New York, Longmans, 1912, 360 pp.

9. Jensen, G.: Ueber circuläre Gefässsutur. Arch. f. klin.Chir., 1903, xlix, 938-998.

10. Lobenhoffer, W.: Funktionsprüfungen an transplantierten Nieren. Mitt.a.d. Grenzgeb. d. Med. u. Chir., 1913, xxvi, 199-238.

11. Murphy, J.B.: Resection of arteries and veins injured in continuity - end-to-end suture - experimental and clinical research. Med. Record, 1897, li, 73-88.

12. Payr, E.: Beiträge zur Technik der Blutgefäss- und Nervennaht nebst Mittheilungen über die Verwendung eines resorbirbaren Metalles in der Chirurgie. Arch.f.klin. Chir., 1900, lxii, 67-93.

13. Quinby, W.C.: Functions of the kidney when deprived of its nerves. Jour. Exper. Med., 1916, xxiii, 535-548.

14. Stich, R., Makkas, M., and Dowman, C.E.: Beiträge zur Gefässchirurgie. Circuläre Arteriennaht und Gefässtransplantationen. Beitr. z. klin. Chir., 1907, liii, 113-160.

15. Stich, R.: Ueber den heutigen Stand der Organtransplantationen. Deutsch. med. Wchnschr., 1913, xxxix, 1865-1868.

16. Ullmann, E.: Experimentelle Nierentransplantation. Wien. klin.Wchnschr., 1902, xv, 281-282.

17. Unger: Nierentransplantation (mit Epidiaskopdemonstrationen). Deutsch. med. Wchnschr., 1909, xxxv, 905.

18. Villard, E. and Tavernier, L.: La transplantation du rein. Presse méd., 1910, xviii, 489-492.

19. Zaaijer, J.H.: Zirkuläre und laterale Venennaht. Zentralbl.f.Chir., 1910, xxxvii, 1283-1285.