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Three Patterns of Extra-Testicular Venous Drainage in the Rabbit

Divergence from a Traditional Concept

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Summary. Seventy-eight male New Zealand white rabbits were autopsied and found to have variable left extra-testicular venous anatomy. Our observations reveal that in the rabbit the left testis is drained in one of three ways, identified as either A (18%), B (30%) or C (52%) – type drainage. The right testicular vein in all cases drained directly into the inferior vena cava immediately superior to the right iliolumbar vein.

In type A drainage, the left testicular vein drained directly into the inferior vena cava at the level of the left iliolumbar vein. In type B drainage, the left testicular vein emptied into the left iliolumbar vein, which in turn drained into the inferior vena cava. In type C drainage both the left testicular and iliolumbar veins anastomosed to form a "lumbotesticular" trunk which emptied directly into the left renal vein.

These three patterns of left venous vascular anatomy in the rabbit can be explained on the basis of their embryologic development. Our observations suggest that it is the caudal segment of the left pelvic subcardinal vein and its anastomosis with the caudal cardinal complex which persist as the left testicular vein and that the more cranial segment of this vein, heretofore presumed to remain patent, atrophies to the level of the developing left renal vein.

Key words: Venous drainage – Left testis – Rabbit

Introduction

Historically, the pattern of venous drainage of the mammalian testis conforms to two basic anatomic edicts. The first is that secondary to embryologic development, the right and left venous routes are not bilaterally symmetric. The second, or perhaps a specific elaboration of the first, is that

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the right testicular vein (internal spermatic vein) drains directly into the inferior vena cava and the left testicular vein drains indirectly into the inferior vena cava generally by way of the left renal vein (Arey 1966; Balinsky 1970; Tuchmann-Duplessis and Haegel 1974; Setchell 1970). This latter fact has been used to explain the almost universal unilaterality of left-sided varicocele in humans (Dubin and Amelar 1971; Saypol 1981) and the subsequent reduction in both spermatogenic function and fertility potential in the presence of varicocele (Saypol 1981; Cameron et al. 1980).

In an attempt to verify that this typical sinistral vascular drainage pattern from the testicle to the renal vein occurs in the rabbit, a search of the anatomic literature was undertaken. Although the general vascular anatomy of the rabbit has been described (Bensly 1938; Craigie 1973) and the rabbit has been commonly used as a model of mammalian physiology (Kaplan and Timmons 1979) particularly for a variety of testicular blood vessel-related studies (Waites et al. 1975; Larson et al. 1974; Brown and Waites 1972; Young and Hollenberg 1977), we could find no pertinent information regarding extra-testicular vascular drainage in this widely used experimental animal.

This paper describes three principal routes of testicular venous return found in the rabbit.

Materials and Methods

Observations were made on 78 biologically fertile male New Zealand white rabbits housed and fed under routine conditions by the Department of Animal Resources.

Each rabbit was anaesthetized by injecting 1 cc ketamine hydrochloride (100 mg/ml) and 1/2 cc xylazine (20 mg/ml) into a marginal ear vein after which a large vertical abdominal incision was made extending from the xyphoid process to the symphysis pubis. Both inguinal canals were dissected by an incision which extended through the scrotum, clearly exposing the intact spermatic cord and testicle. The abdominal and pelvic viscera were retracted to expose the inferior vena cava, left and right testicular veins and iliolumbar veins. At this time the pattern of right and left extra-testicular venous anatomy was visually defined and photographically recorded. In some rabbits, the inferior vena cava was ligated superiorly immediately above the junction of the renal veins. The vena cava was then cannulated with flexible vinyl tubing (BioLab). The cannula was secured in the posterior segment of the vena cava above its bifurcation into the left and right common iliac veins. Both renal veins were also ligated at the hilus of the kidney. The segment of the inferior vena cava thus isolated, renal vein segments and tributaries of these veins were perfused by direct pressure through the cannula with blue latex solution (Ward's Natural Science). Following complete replacement of the blood, the surrounding soft tissue was removed, and the perfused vascular anatomy was photographically recorded.

In some animals both testicular veins and iliolumbar veins were perfusion fixed with Bouin's fluids and routinely processed for light microscopic observation. Paraffin sections (5 μm) were stained with hematoxylin and eosin.

Results

The vascular pattern of systemic venous return in the rabbit testis was consistent on the right side but variable on the left. In all rabbits observed the right testicular vein drained directly into the inferior vena cava immedi-

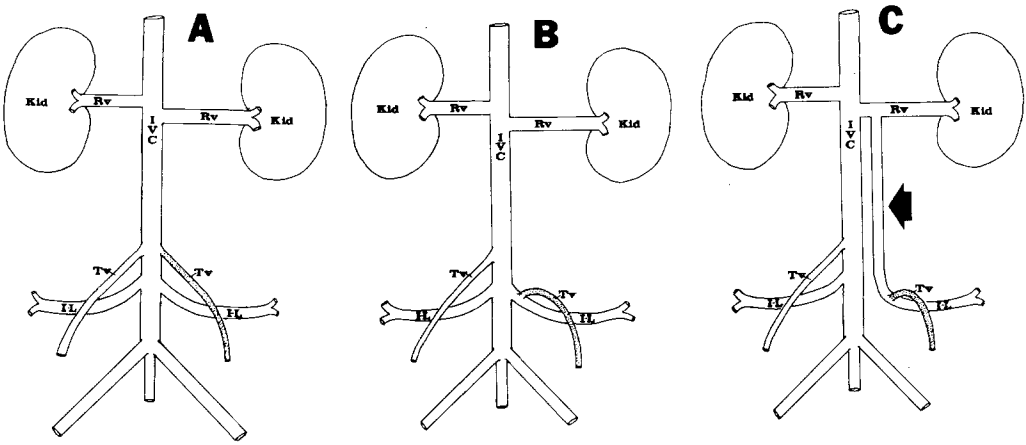

Fig. 1. These schematic drawings illustrate the three types of extratesticular venous drainage patterns (types *A*, *B* and *C*) found in the rabbit wherein anatomical variation occurs on the left. *Arrow* indicates the "lumbotesticular" trunk. *Kid* Kidney, *Rv* renal vein, *IVC* inferior vena cava, *Tv* testicular vein, *I–L* iliolumbar vein

ately superior to the right iliolumbar vein (Fig. 1). It crossed the right ureter and iliolumbar vein anteriorly prior to entering the inferior vena cava.

The course of the left testicular vein was not consistent but conformed to one of three anatomical patterns identified as either type A, type B or type C drainage (Fig. 1).

Type A Drainage. This pattern of left-sided extra-testicular venous return was found in fourteen (18%) of the 78 rabbits observed. In these rabbits the left testicular vein drained directly into the inferior vena cava immediately superior to the caval junction of the left iliolumbar vein and at the same level as the right testicular vein. The left testicular vein crossed the left iliolumbar vein and ureter anteriorly before entering the inferior vena cava (Fig. 2).

Type B Drainage. This pattern was found in twenty-three (or 30%) of the rabbits observed. In these rabbits the left testicular vein drained directly into the left iliolumbar vein close to its pelvic junction with the inferior vena cava. The testicular vein crossed the left iliolumbar vein and ureter anteriorly (Fig. 3).

Type C Drainage. The greatest number of rabbits exhibited this pattern of extra-testicular venous return. There were forty-one (or 52%) animals in which the left testicular vein drained into a venous segment confluent with the left iliolumbar vein, which did not drain directly into the inferior vena cava as in types A and B drainage. Instead, this venous segment, the "lumbotesticular" trunk, turned superiorly, ran parallel with the inferior vena cava and joined directly with the left renal vein close to its junction with the inferior vena cava (Fig. 4).

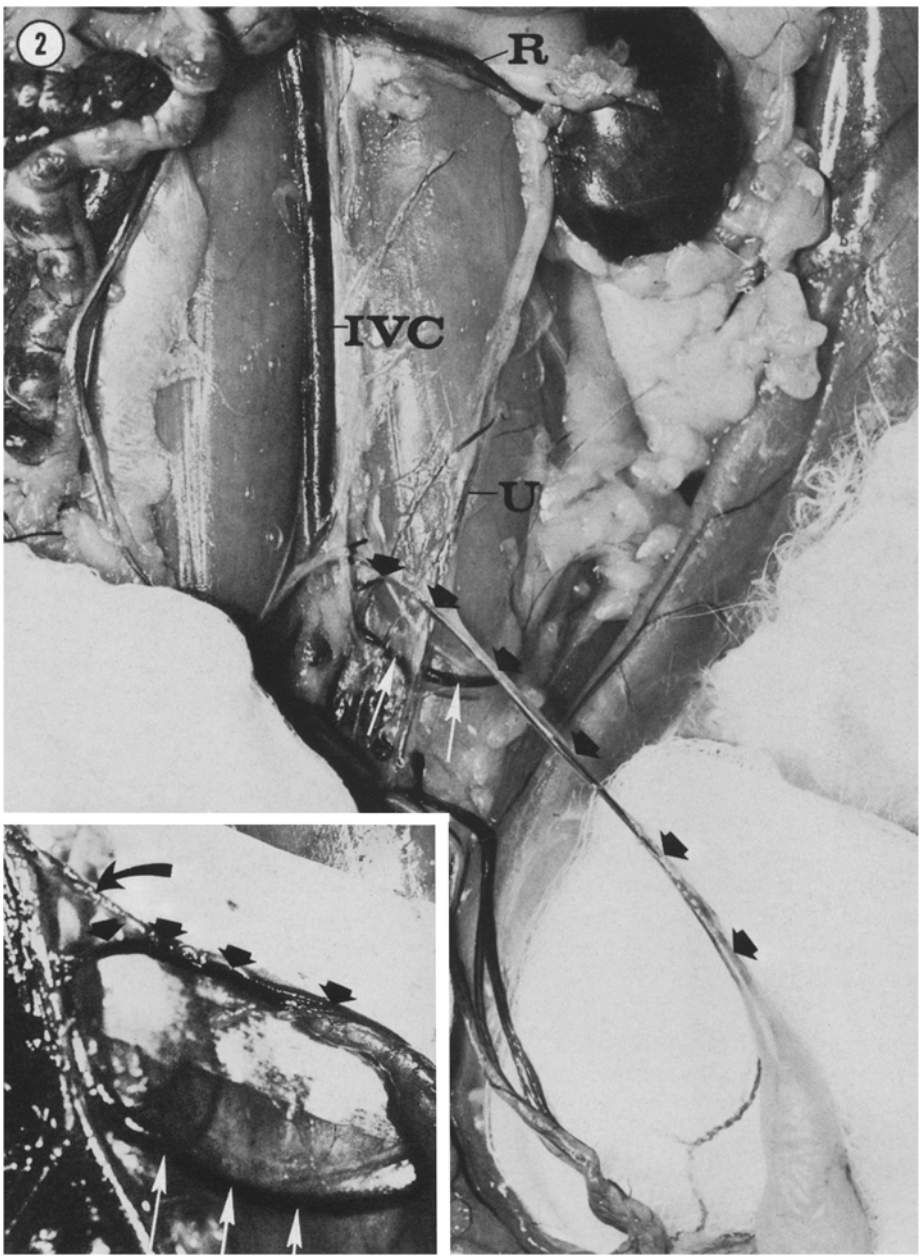

Fig. 2. In type A drainage (18% of the rabbits observed) the left testicular vein (*solid arrows*) drained directly into the inferior vena cava (*IVC*) as did the iliolumbar vein (*white arrows*). *R* renal vein; *U* ureter. *Inset:* This higher magnification of the same specimen illustrates not only separate drainage of the left testicular vein (*solid arrows*) and the left iliolumbar vein (*white arrows*) but also the left testicular artery (*curved arrow*)

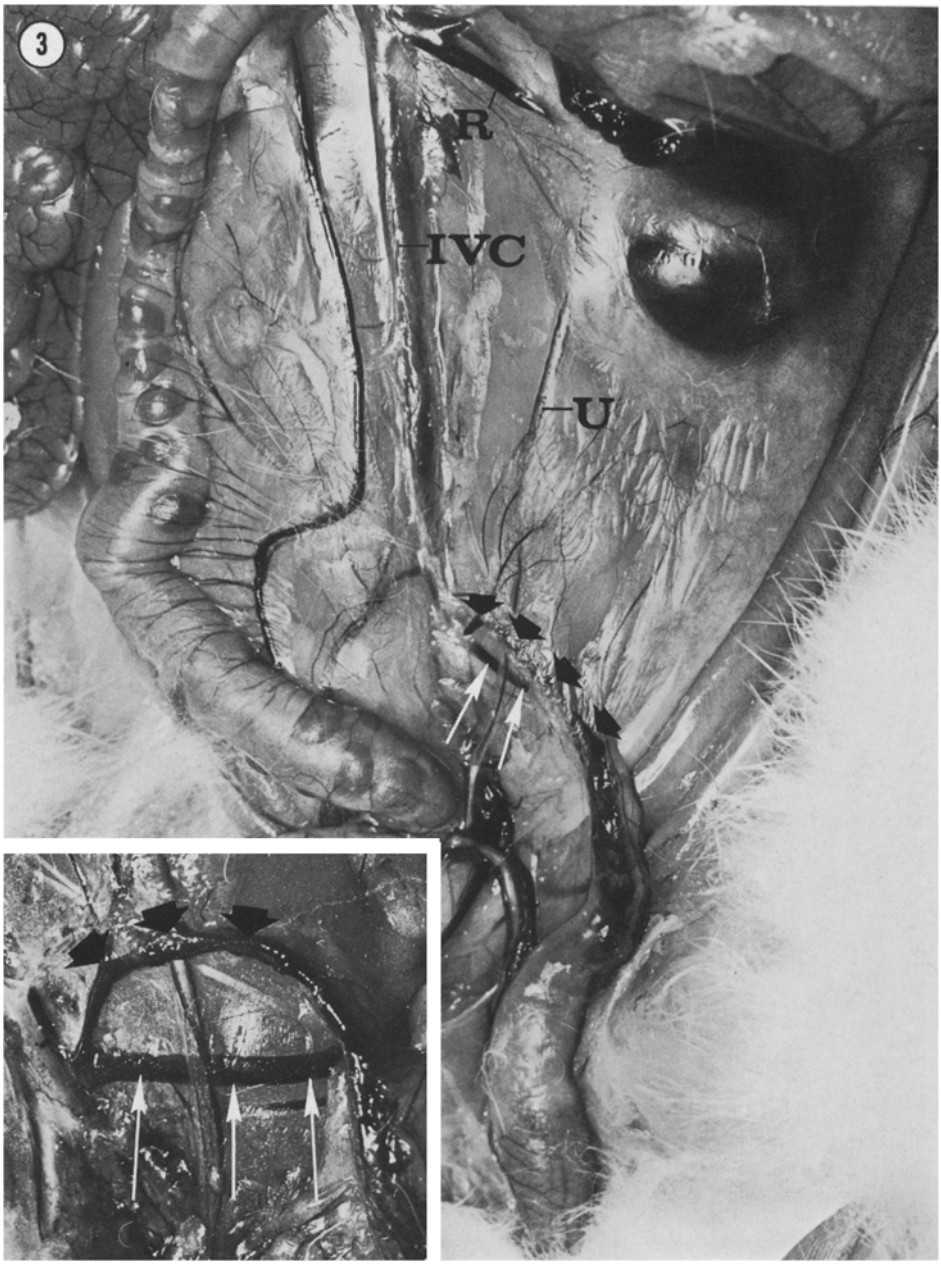

Fig. 3. In type B drainage (30% of the rabbits observed) the left testicular vein (*solid arrows*) drained into the left iliolumbar vein (*white arrows*) which then drained into the inferior vena cava (*IVC*). *R* renal vein; *U* = ureter. *Inset:* At higher magnification of the same specimen following additional dissection, this arrangement of left testicular (*solid arrows*) and iliolumbar (*white arrows*) veins can be seen to better advantage

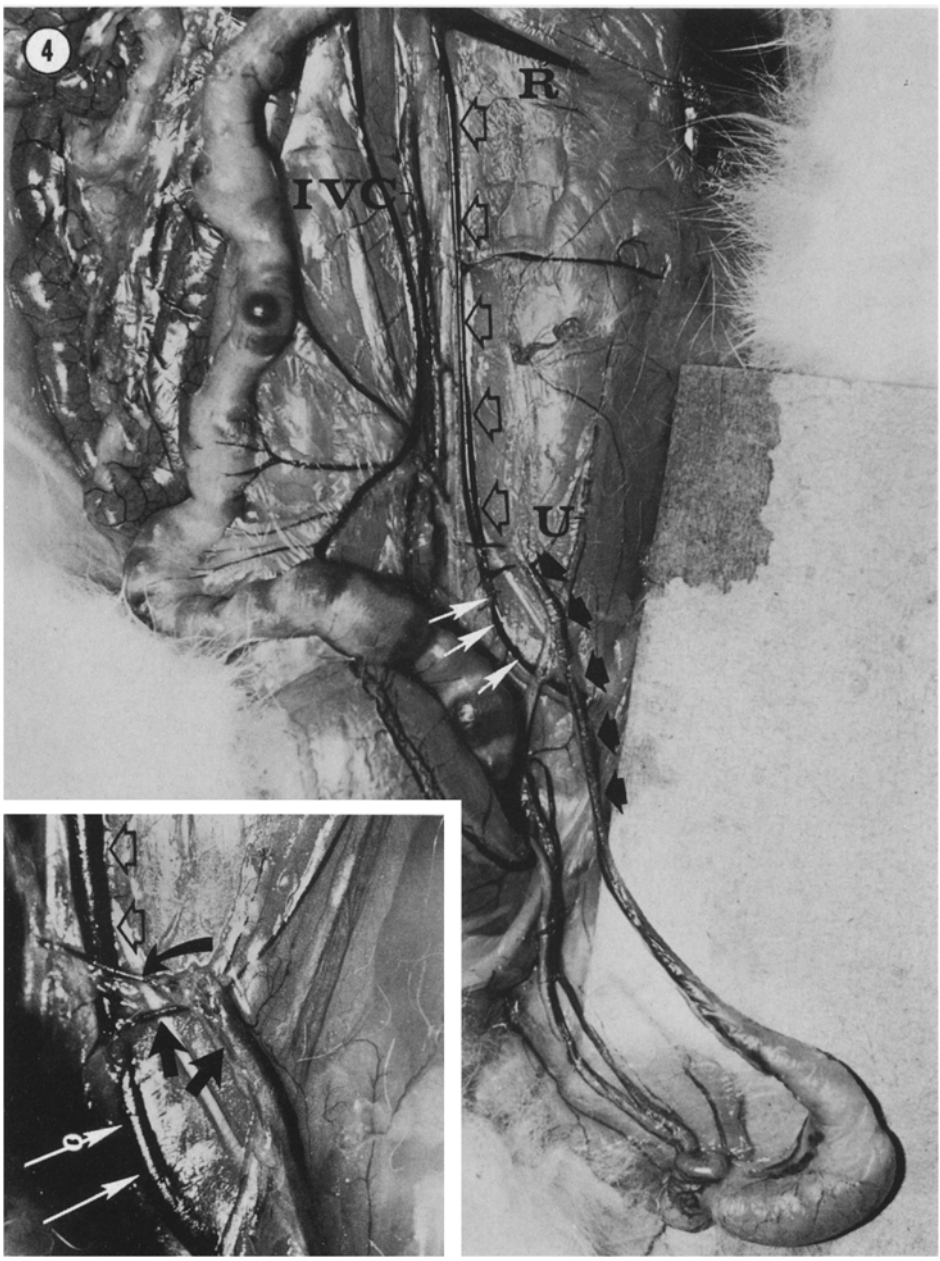

Fig. 4. In type C drainage (52% of the rabbits observed) the left testicular vein (*solid arrows*) drained directly into the left iliolumbar vein (*white arrows*). The resulting common trunk (*hollow arrows*) did not drain into the inferior vena cava (*IVC*) as in type B drainage (see Fig. 3) but run parallel wih the IVC and entered into the left renal vein (*R*). We have identified this common trunk as the "lumbotesticular" trunk (*hollow arrows*). *U* ureter. *Inset:* This vascular pattern of the left testicular vein (*solid arrows*), left iliolumbar vein (*white arrows*) and the "lumbotesticular" trunk (*hollow arrow*) of the same specimen is illustrated at higher magnification. Also pictured is the left testicular artery (*curved arrow*)

Testicular, iliolumbar veins and where present, the "lumbotesticular" trunk from each drainage pattern (types A, B, and C) were filled with latex by retrograde perfusion. In all cases the latex quickly replaced the blood in the inferior vena cava, renal and iliolumbar veins, and the "lumbotesticular" trunk but was prevented from entering testicular veins by the presence of one way venous valves. Latex entered the testicular vein only after "milking" the vein at the valve site and then the latex only filled the vessels to the level of the next venous valve. The "milking" technique was utilized to pass the latex through the testicular vein.

In some cases, the extra-testicular pelvic veins from each drainage pattern were fixed in Bouin's and processed for light microscopy. Examinations of sections parallel with the long axis of the vessel confirmed that only testicular veins contained valves.

Discussion

Our results reveal that in the rabbit the left testis is drained in one of three ways, which we have identified as type A, type B and type C drainage. The gross vascular anatomy of the right testicular vein in all cases was consistent and conformed to the expected course of direct caval drainage.

It is apparent that although the pattern of left extra-testicular venous drainage in the rabbit is variable, this variability does not influence spermatogenic function nor, presumably, fertility potential, since all the rabbits utilized in this study were proven breeders.

If one accepts the general concept that in mammals, except for the Monotremata, Marsupialia and some Dasypodidae, the left testicular vein drains directly into the left renal vein (Beddard 1909; Setchell 1970), it is surprising that such is not the case in any of the animals observed in this study.

The basic concept of venous vascular variability, however, is not contrary to the diversity of venous vascular development as found in other visceral organs. The development of pelvic organ venous vasculature is a direct result of the embryologic origin and differentiation of the abdominopelvic inferior vena cava (Arey 1966; Balinsky 1970). In those species where there is only one inferior vena cava, this structure arises principally from the right sub- and supracardinal veins while the homologous structures on the left are resorbed or modified (Arey 1966; Balinsky 1970). In such a case, the right testicular vein would retain its original direct connection to the inferior vena cava as the superior portion of the right caudal subcardinal vein and the left testicular vein would retain its drainage to the inferior vena cava indirectly through anastomoses of the superior portion of the left caudal subcardial vein and left renal vein (Arey 1966; Balinsky 1970).

If this were true, as we have been a priori led to believe, then the right testicular vein should drain into the inferior vena cava below the level of the right renal vein and the left testicular vein should unerringly course to the left renal vein. This is obviously not the case in rabbits, as examplified by our observations. The three types of drainage patterns are likely the

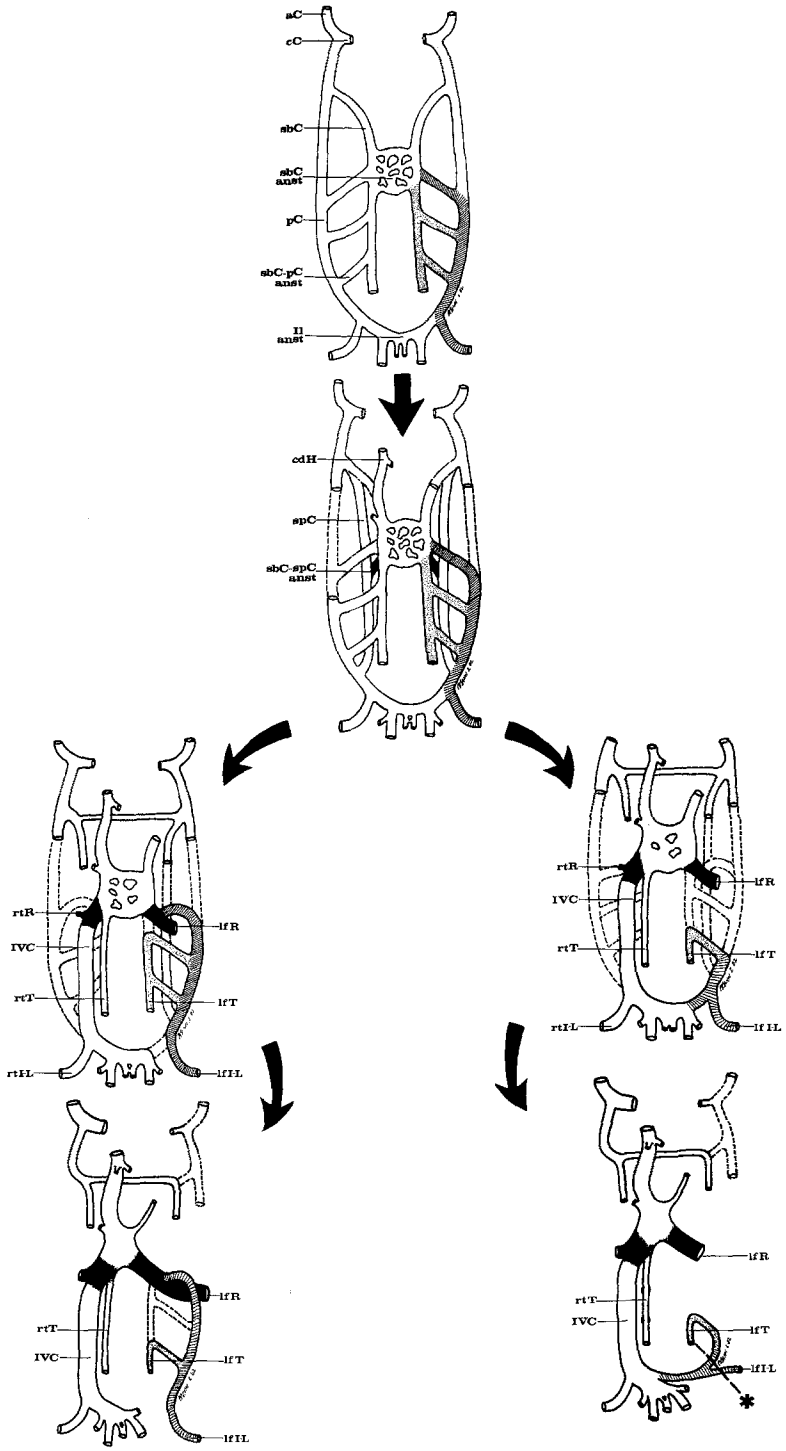

Fig. 5. This schematic flow chart of proposed developmental steps in the formation of the venous vasculature in the rabbit illustrates two possible routes (*1* and *2*) for the development of type C drainage (route 1) and types A and B drainage (route 2). For type A drainage resorption would occur to the level indicated in route 2 (*asterisk*) presumably during elongation of the inferior vena cava. *aC* anterior cardinal, *cC* common cardinal, *sbC* subcardinal, *sbc anast* subcardinal anastomosis, *pC* posterior cardinal, *sbC-pC anast* subcardinal-posterior cardinal anastomosis, *Il anast* iliac anastomosis, *cdH* caudal hepatic, *rt R* right renal, *lf R* left renal, *IVC* inferior vena cava, *rt* right testicular, *lf T* left testicular, *Rt I-L-rt* iliolumbar, *lf I-L* left iliolumbar

result of variable embryologic development which can be explained in the following ways.

Type A drainage may well result from the atrophy of the superior portion of the left caudal subcardinal vein to the level of the left intersubcardinal anastomotic complex (or developing left renal vein) and its persistent patency with the developing inferior vena cava through the subcardinal/postcardinal anastomosis. Resorption of a common trunk, presumably during caval elongation, would thus provide independent drainage from the left testicular and iliolumbar veins (see Fig. 5, route 2).

Type B drainage could develop in a manner similar to that of type A with one major exception: the most caudal portion of the left postcardinal vein is not resorbed as is the case in type A drainage, thus providing a common venous trunk for the left testicular and iliolumbar veins (see Fig. 5, route 2). Finally, type C, or the more typical vascular pattern expected likewise could result from atrophy of the superior portion of the left caudal subcardinal vein to the level of the developing left renal vein with retention of an anastomotic connection with the left caudal postcardinal vein. This latter segment (the presumptive "lumbotesticular" trunk) subsequently loses its connection with the developing inferior vena cava but retains its anastomotic connection with the developing left renal vein (see Fig. 5, route 1).

An additional fact that supports our observations concerning the probable origin of vessels draining the testes lies within the lumen of the testicular vein. This vein is unique among veins draining visceral organs in that it contains valves (Warwick and Williams 1973). It would appear that as in other species examined (Saypol et al. 1981, Warwick and Williams 1973), it is the subcardinal vein which develops valves and functions as the testicular vein in post-fetal life. Thus, the contribution of the testicular vein to the overall venous network draining the testicle can be delineated by the vascular segments containing these valves.

In all rabbits observed both testicular veins contained valves and are therefore most likely derived from the subcardinal veins, as would be expected. The iliolumbar veins and the "lumbotesticular" trunk did not contain valves. This indicates that the embryonic origin of these veins arises from different vascular primordia. Likewise, our observations suggest that the left posterior cardinal vein develops to form the valveless "lumbotesticular" trunk and support the subcardinal origin of the testicular vein.

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