CARDIAC MUSCLE RELATIONS OF THE CORONARY SINUS, THE OBLIQUE VEIN OF THE LEFT ATRIUM AND THE LEFT PRECAVAL VEIN IN MAMMALS

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INTRODUCTION

Many authors (reviewed by Lechner, 1942) have noted the presence of striated cardiac muscle in the walls of the pulmonary veins and the right precaval vein (superior vena cava) near their entrance to the heart. Few workers have made similar studies of the coronary sinus (Keith, 1902; Tandler, 1913; Papez, 1920; Lechner, 1942), and there is considerable divergence of opinion among these investigators. No such study of the left precaval vein or the oblique vein of the left atrium appears to have been carried out. During a recent study of the atrial cardiac ganglia in many mammals, including man, King & Coakley (1958) noted the presence of cardiac muscle in the oblique vein of the left atrium and the left precaval vein, and in some specimens it was observed that many of the fibres of this musculature closely resemble histologically the fibres of the sinu-atrial (S.A.) and atrioventricular (A.V.) nodes. In the present work a more detailed investigation of the relation of the cardiac muscle to the coronary sinus, the left precaval and the oblique vein has been made.

MATERIALS AND METHODS

The twenty-seven hearts examined comprised the following, the number of hearts from each species being indicated:

Specimens with left precaval vein: platypus (*Ornithorhyncus anatinus*, 1), wallaroo (*Macropus robustus rubens*, 1), hedgehog (*Erinaceus europaeus*, 1), mole (*Talpa europaea*, 1), rabbit (*Oryctolagus cuniculus*, 1), laboratory rat (*Rattus norwegicus*, 2), fruit bat (*Pteropus* sp., 1), tree shrew (*Tupaia* sp., 1).

Specimens with oblique vein of left atrium: guinea-pig (*Cavia porcellus*, 2), cat (*Felis domesticus*, 2), dog (*Canis canis*, 2), porpoise (*Phocaena phocaena*, 1), pig (*Sus scrofa*, 2), domestic ox (*Bos taurus*, 3), sheep (*Ovis aries*, 1), horse (*Equus caballus*, 1), rhesus monkey (*Macacus mulatta*, 1), man (*Homo sapiens*, 3; 1 adult and 2 infants).

The animals listed above are divided into two groups according to the type of vein present in the particular hearts examined. It obviously could be maintained that, because so few specimens of each species were examined, it is not possible or safe to be dogmatic as to whether the type of vein observed is normally present in a particular species or whether it is a variation or abnormal arrangement in the individual heart examined. A survey of the literature, however, indicates that in those of our specimens that have a left precaval vein, this feature appears to be

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normal for these animals, e.g. platypus, wallaroo, hedgehog, mole and many rodents (Weber, 1904*a*; Benninghoff, 1933), hedgehog and mole (Dobson, 1882), rabbit (Krauze, 1868), rat (Greene, 1955), fruit bat (Grosser, 1901) and tree shrew (Weber, 1904*b*). Again, an oblique vein of the left atrium is stated to be the usual arrangement in the guinea-pig (James, 1904), cat (Reighard & Jennings, 1935), dog (Bradley, 1943), Cetacea and Ungulates (Weber, 1904*a*), horse (Chauveau, 1891) and Primates (Weber, 1904*a*).

In most cases, the entire heart was embedded in paraffin and serially sectioned in a plane parallel to the A.V. sulcus. From the hearts of the horse and pig, blocks of tissue were removed and paraffin or frozen sections prepared. The staining techniques were haematoxylin and eosin, iron haematoxylin and picrofuchsin (van Gieson), Masson's trichrome stain (using light green), pyridine-silver, and the Ranson, Smith-Quigley and Bielschowsky-Gros silver methods.

OBSERVATIONS

The standardized diagrams in Text-fig. 1 show the atria viewed from the cranial aspect and depict the left precaval vein (A) and the two types of oblique vein (B, C) observed in the present study. The dots indicate the position of the subepicardial ganglia previously investigated (King & Coakley, 1958). Numerous ganglia and nerves were found to accompany the left precaval vein, the oblique vein and the coronary sinus.

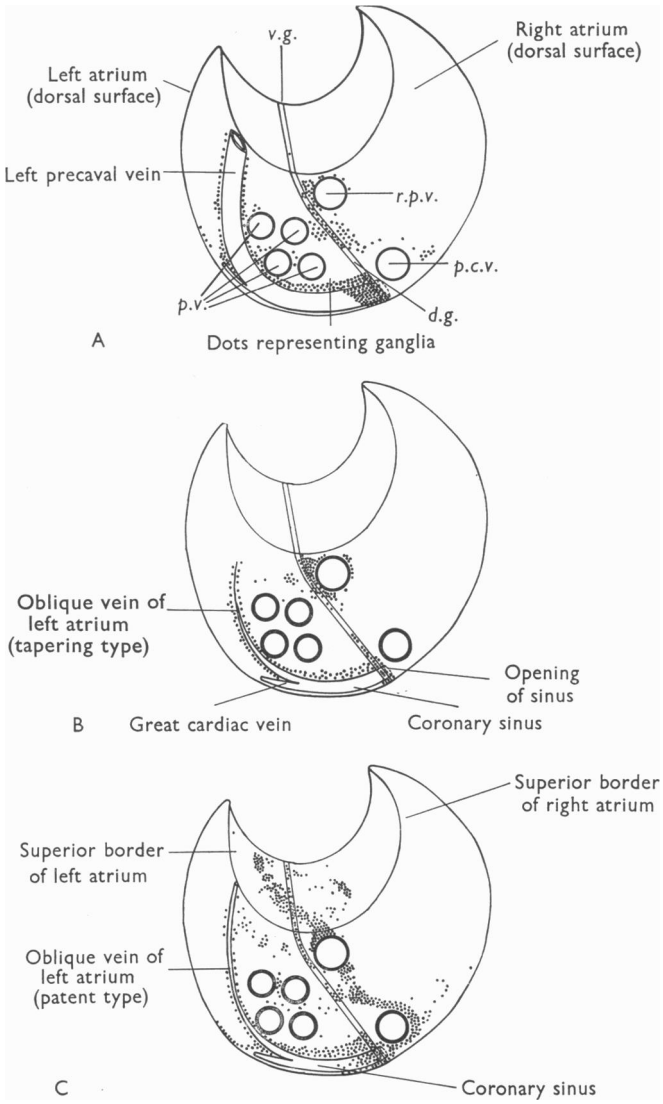
The patent type of oblique vein (Text-fig. 1 C) present in our specimens in the pig, ox, sheep and horse, extends cranially as a narrow patent vessel beyond the atrium, while the tapering type (Text-fig. 1 B), in the guinea-pig, cat, dog, porpoise, rhesus monkey and man, becomes very slender and ends blindly on the dorsal wall of the left atrium. In all the hearts, the left extremity of the coronary sinus is considered to be the site of junction of the left (great) cardiac vein with the oblique vein or the left precaval vein.

In all the hearts, cardiac muscle was found to be closely associated with the coronary sinus and the left precaval or oblique vein. In some hearts this muscle is histologically identical with ordinary cardiac muscle, but in the hedgehog, mole, rabbit, guinea-pig, cat, dog, pig, horse, tree shrew and rhesus monkey many of the muscle fibres are narrower, paler staining and less distinctly striated than those of the neighbouring atrial myocardium, and in these respects they resemble the fibres of the S.A. and A.V. nodes (Pl. 1, fig. 6). These fibres are found throughout the whole length of the coronary sinus but are limited to the caudal half or less of the oblique vein and left precaval vein. In the guinea-pig, there is in addition a mass of these 'nodal' fibres on the dorsal wall of the left atrium, mainly lying dorsal to the caudal half of the oblique vein. It is about one-third of the transverse width of the atrium and the fibres become continuous cranially and caudally with those in the wall of the vein.

The arrangement of the cardiac muscle associated with these veins varies according to the type of vein present.

The left precaval vein has a complete coat of cardiac muscle, the fibres being arranged in a circular or spiral fashion and replacing the venous tunica adventitia and media (Pl. 1, fig. 1). Although in general these fibres are separate from the

atrial myocardium, at a few places continuity is established. The cardiac muscle coat extends cranially beyond the limits of the specimens (i.e. beyond the cranial border of the left atrium). Caudally it is continuous with the cardiac muscle related to the coronary sinus, which is arranged in a similar manner (Pl. 2, fig. 5), and which in



Text-fig. 1. Standardized diagrams of cardiac atria of tree shrew (A), guinea-pig (B) and domestic ox (C). *d.g.*, dorsal interatrial groove; *p.c.v.*, postcaval vein; *p.v.*, pulmonary veins; *r.p.v.*, right precaval vein; *v.g.*, ventral interatrial groove.

turn, at the entry of the sinus into the right atrium, becomes continuous with the myocardium of the atrium and with the fibres of the A.V. node, this latter continuity involving both the 'nodal' fibres and the ordinary cardiac muscle in the wall of the sinus.

In those hearts with the patent type of oblique vein the cardiac muscle related to both the vein and the coronary sinus has the same arrangements as in those hearts with a left precaval vein (Pl. 1, fig. 2).

In the case of the tapering type of oblique vein the cardiac muscle arrangements are different and vary somewhat in the different animals. In general the cardiac muscle lies outside the venous tunica adventitia and media and does not form a compact and complete coat around the vein (Pl. 1, fig. 4). For the most part it is quite separate from the myocardium of the left atrium, though continuity is established at a number of points along the course of the vein. Most of the fibres run parallel to the vein but a few of them form rings or spirals around the nerves accompanying the vein. In the guinea-pig, cat and porpoise the muscle forms a loose network around or beside the vein (Pl. 1, fig. 4), and while in one dog this arrangement was present, in the other the muscle formed a compact bundle close beside the vein. In the rhesus monkey (Pl. 1, fig. 3) the muscle forms rounded bundles encircling the vein, while in man it consists of strands intermingled with nerves, ganglia and subepicardial connective tissue. Cranially, the cardiac muscle fibres taper and end blindly in the subepicardial connective tissue beyond the vein, though in man most of them become continuous with the myocardium of the dorsal wall of the left atrium. Caudally, the muscle fibres become continuous with the cardiac muscle related to the coronary sinus, which forms a complete coat around the sinus and ends in the same manner as described above in the hearts with a left precaval or patent type of oblique vein.

Thus in all the hearts, the cardiac muscle arrangement in relation to the coronary sinus is the same. While the arrangement of the muscle in relation to the left precaval vein and the patent and tapering types of oblique vein varies with the type of vein, the presence or otherwise of 'nodal' fibres in these veins does not appear to be so related. In all these veins, numerous nerve fibres, both medullated and non-medullated lie among the muscle fibres.

DISCUSSION

In all the hearts studied the cardiac muscle related to the coronary sinus has a constant arrangement; namely that it extends along the entire length of the sinus and forms a complete (for the main part circular) coat replacing the tunica adventitia and media found in veins generally. The arrangement in the other veins studied varies according to the type of vein present. In the left precaval vein and the patent type of oblique vein, the cardiac muscle extends beyond the cranial border of the left atrium (i.e. outside the limits of the heart specimens) and is arranged in the wall of these veins in the same manner as in the coronary sinus. In the tapering type of oblique vein, the cardiac muscle lies outside the tunica adventitia of the vein, is sparser and does not form a complete coat for the vein. So far as the coronary sinus is concerned, these results are at variance with those of previous workers. Lechner (1942) found considerable variation among species; e.g. in the coronary sinus he found no cardiac muscle in the ox, none or only at the termination of the sinus in rodents, only at the end of the sinus in marsupials, a partial covering in the cat, and extending only for a short distance along the sinus in insectivores. Extension of cardiac muscle into the wall of the sinus in man has been noted by Keith (1902),

Tandler (1913) and Papez (1920). Papez observed that in the bovine heart the coronary sinus is surrounded by cardiac muscle for a distance of several inches.

In a number of the animals studied in the present work, many of the muscle fibres related to the coronary sinus and the left precaval or oblique vein were found to resemble the fibres of the S.A. and A.V. nodes. With regard to the significance of these fibres, the work of Shaner (1929) and Jones (1932) is pertinent. These authors described the temporary appearance of a left A.V. node in the embryo of the calf (Shaner) and human (Jones), and it might be considered that the muscle fibres in the present series may represent the persistence of such a structure. On the other hand, from their position in relation to the coronary sinus which is developed from the left horn of the sinus venosus, they may be regarded as analogous to the normal S.A. node related to the junction of the right precaval vein with the part of the right atrium derived from the right horn of the sinus venosus, and in this respect they might be considered as a left S.A. node. However, the fact that in all cases the fibres are directly continuous with those of the 'normal' A.V. node renders it more probable that they should be regarded merely as an extension of the latter into the walls of the veins.

SUMMARY

1. Several mammalian hearts have been examined histologically to ascertain the cardiac muscle relationships of the coronary sinus and of the left precaval vein or the oblique vein of the left atrium.

2. Two types of oblique vein are described, the patent and the tapering type.

3. In all specimens the coronary sinus is completely covered by striated cardiac muscle which replaces the tunica adventitia and media.

4. The left precaval vein and the patent type of oblique vein have the same cardiac muscle arrangements as the coronary sinus, whereas the tapering type of oblique vein has a sparser and less complete cardiac muscle coat which lies outside the adventitia of the vein.

5. In some of the hearts many of the muscle fibres in the wall of the coronary sinus and of the left precaval or oblique vein resemble the fibres of the S.A. and A.V. nodes and are continuous with the A.V. nodal fibres. They are considered to be extensions of the A.V. node into the walls of the veins.

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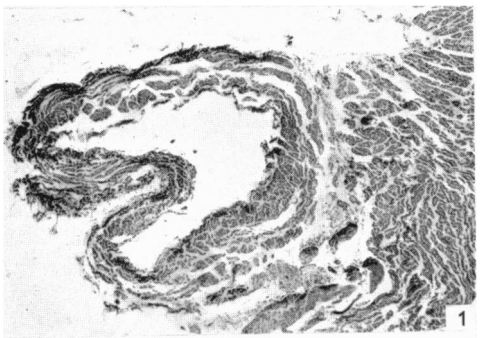

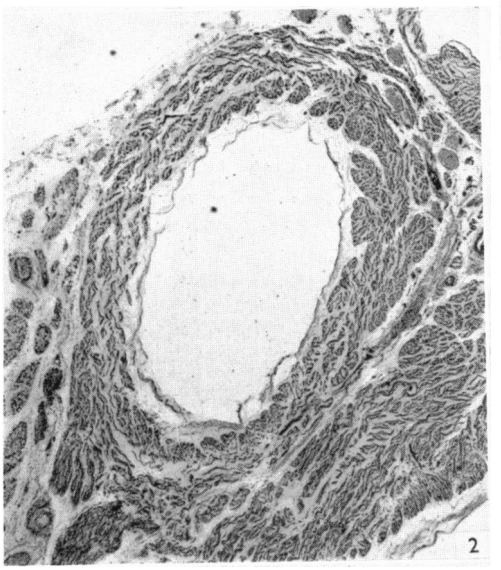

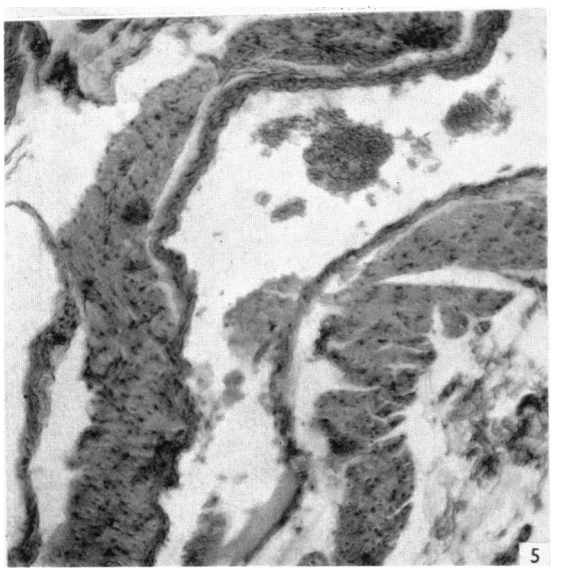

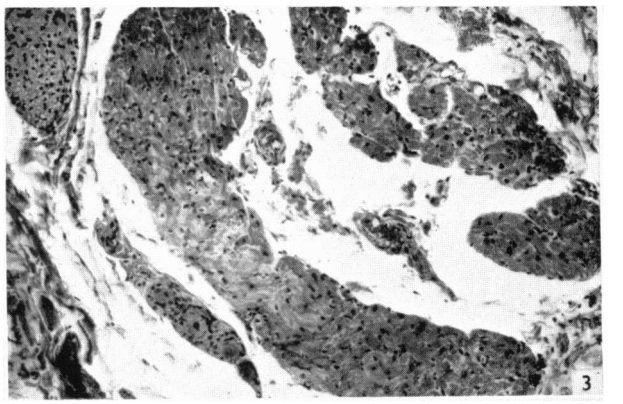

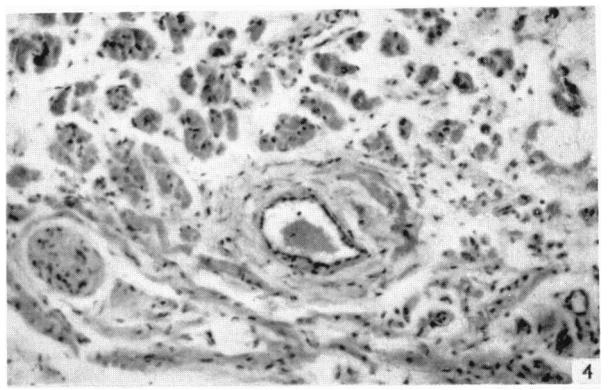

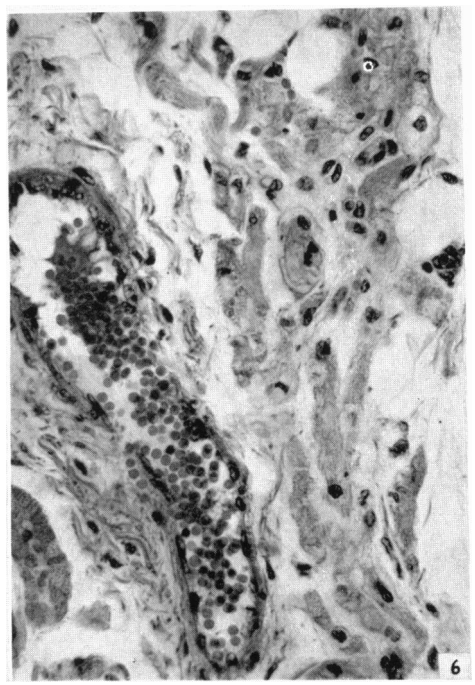

COAKLEY AND SUMMERFIELD KING—CARDIAC MUSCLE RELATIONS IN MAMMALS

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EXPLANATION OF PLATE

(All the sections illustrated were stained with haematoxylin and eosin.)

Fig. 1. Transverse section of left precaval vein in the rabbit. ×25. Note the cardiac muscle replacing the adventitia and media of the vein.

Fig. 2. Transverse section of oblique vein (patent type) in the sheep. ×18. Note the cardiac muscle replacing the adventitia and media of the vein.

Fig. 3. Transverse section of oblique vein (tapering type) in the rhesus monkey. ×100. Note the cardiac muscle bundles outside the adventitia of the vein.

Fig. 4. Transverse section of oblique vein (tapering type) in the guinea-pig. ×130. Note loose arrangements of cardiac muscle around and outside the adventitia of the vein.

Fig. 5. Longitudinal section of coronary sinus in the rhesus monkey. ×70. Note the cardiac muscle replacing the adventitia and media of the vein.

Fig. 6. Longitudinal section through the caudal end of the oblique vein in the guinea-pig. ×300. Note the pale-staining 'nodal' fibres on the right compared with the ordinary atrial myocardium (bottom left).