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REPORT CVI.

INVESTIGATION OF THE BUNDLE OF HIS IN RABBITS' EXCISED HEARTS PERFUSED WITH LOCKE'S FLUID.*

By L. N. HESKETH BIGGS, M.D., EDIN.

ONCE the rabbit's heart has settled down to its work after excision—say in three-quarters of an hour to an hour—it is remarkable how much cutting about it will stand without marked disturbance. On several occasions all the right side of the heart was removed; on another both ventricles were removed, leaving only the septum; and on yet another the septum and the right side of the heart were cut away, leaving the left ventricle hanging by a strip about 5 mm. wide; and still in all these cases the tissues continued giving very good contractions, considering how little fluid could possibly have reached them after such extensive section of vessels.

Cutting any of the ultimate branches of the A-V bundle makes no discernible difference. I have divided both the descending and the anterior divisions of the left branch of the A-V bundle, as it emerges through the inter-ventricular septum, but noticed absolutely no change at all except a distinct, though temporary, lengthening of the As-Vs interval. Similarly I cut through the left division before it branches (so far as is as yet known), but obtained no result, though I cut almost through the entire thickness of the septum. I also tried dividing the right division, first of all in its ramifications and then closer and closer to its origin, but all was of no avail, the ventricles continuing to respond to the auricular impulses undisturbed.

In one experiment I carefully separated the right from the left ventricle, and placed a pin with lever attached in the tip of each ventricle, and tried to block one side without the other, but found that the most careful sections of the left and right branches separately produced no block of its half, and, as in every other experiment, finally one snip with the scissors penetrating the entire thickness of the septum blocked both ventricles simultaneously.

This seems to entirely contradict the usual view that the fibres of the A-V bundle do not fuse with those of the septum in its upper part, but continue enclosed in a sheath a long way down the septum, uniting only in the lower third, as otherwise it would have been possible, by dividing all the main branches, to produce the same effect as by section of the A-V bundle itself, either before it reaches the pars membranacea septi or just before its division into right and left. This I never found it possible to do; for, unless the bundle was divided just as high up as one could go without injuring the cusp of the aortic valve—that is to say, just about its division—one might cut the whole septum across and cut it out, and yet get only a very partial heart-block.

A few of the hearts used had abnormally-developed membranous part of the septum, and in these the A-V bundle seemed to pursue an abnormal course or to divide prematurely, or else its anatomical relations are masked; for division at the spot usually successful produces no heart-block, and it is not till the division is performed high up on the interauricular septum, while the fibres of the bundle are in the auricular cavity, that heart-block is established. Great care has to be exercised in doing this, as frequently the aortic valves begin to leak seriously, and thus render the experiment almost useless.

One may even in such a case carefully dissect away as far as one is able every scrap of muscular tissue from the pars membranacea and the root of the aorta and yet get only a very partial condition of heart-block. I have one heart preserved in alcohol in which this was done, and yet a block was not produced.

It seems as though there were some other path of conduction which can only be divided by an incision at or before the bifurcation of the A-V bundle.

I found further that so long as a minute part of the A-V bundle was left undivided, although section appeared at first to have produced complete block, yet recovery would almost invariably take place to normal rhythm. This might take a considerable time, as though the amount of stimulus that could pass through the small uninjured part of the bundle was insufficient to stimulate the ventricles to contract until their inherent rhythmicity had increased to such a degree that the stimulus plus their increased irritability became effectual. I do not believe that this was in any way to be attributed to an injurious compression of the fibres of the A-V bundle still uncut during the attempted section.

I was unable to find that any part of the A-V bundle supplied any definite part of either ventricle. In one or two experiments it did seem as though one ventricle was more affected than the other, and on one or two occasions as though part of a ventricle was not contracting properly, but it was practically impossible to be certain of the point, and different onlookers of experience gave quite different opinions as to the result obtained.

Thus I infer that so long as a small part of the thickness of the A-V bundle is still intact every part of the ventricles will respond to the auricular stimuli, and that this may be due to the extreme reticulation of the fibres and their tendency to fuse with one another, so that every bundle of muscle fibres may be said to have a universal distribution. Moreover, apart from actual compression, such as Erlanger used, any part of the A-V bundle uncut and uninjured is capable of performing almost the entire function of the whole bundle, and the whole bundle must be cut across or damaged by compression for even a partial state of heart-block to remain for any length of time. For sometimes in these experiments cut after cut was carefully given to the bundle without any sign of heart-block except a lengthening, usually only temporary, of the As-Vs interval, till finally a touch with the edge of a knife, which could not have cut more than a small fraction of a millimetre, has produced total heart-block. Probably the left and right branches of the A-V bundle are not confined in their distribution to their own side of the heart, but supply both ventricles, for it looks as though auricular impulses were always capable, when one of the two primary branches was divided, of reaching both ventricles simultaneously through, presumably, the other uninjured branch.

The details of the procedure adopted for dividing the A-V bundle do not seem to call for mention, except to state that an incision of 2 mm. was ample to produce block in a rabbit's heart. The incision was made at the upper edge of the muscular part of the septum, and ran slightly downwards and backwards. The anterior end of the incision should reach to the line drawn down the centre of the aorta as the heart hangs from the cannula.

As a rule the first cut at the A-V bundle would appear to have produced complete block, with total cessation of the ventricles for a period varying from several seconds to many minutes, but often after a period of independence of the ventricles, auricular extrasystoles would appear in response to the ventricular contractions, and then a gradual recovery take place through 4-1, 3-1, and 2-1 rhythms to the normal, but with a slightly lengthened As-Vs interval, at any rate for a time. A small further cut would then produce dissociation, sometimes absolute and sometimes with auricular extrasystoles following ventricular contractions, but with no vestige of conduction in the normal direction. In these latter cases the Vs-As interval was usually about half the normal As-Vs interval, but varied from half to the same length as the As-Vs interval.

The normal As-Vs interval averages about $\frac{1}{4}$ of the cardiac cycle, or between $\frac{1}{8}$ and $\frac{1}{10}$ of a second. Incising the ventricles generally produced a temporary shortening of the interval, as one would expect as the result of the

* A short extract from the latter half of an M.D. thesis, submitted in April, 1907, which was awarded a gold medal, and towards the experimental expenses of which a grant was made by the British Medical Association.

stimulation, sometimes up to $\frac{1}{10}$ of the cycle, and section of the auricles produced still greater shortening. Incomplete section of the bundle invariably causes a lengthening of the $A\text{-}V\text{s}$ interval for a time, though recovery usually takes place nearly to normal. When section is very nearly complete, the interval may be as long as $\frac{1}{2}$ of the cycle for a considerable period of time before recovery sets in. When the section is very slight the effect is very transient. This rapid recovery made it a difficult matter to at all thoroughly study the different stages of heart-block owing to their shortness.

With a 2-1 rhythm the rate of conduction from auricle to ventricle was generally normal, except at the commencement of the stage, when the $A\text{-}V\text{s}$ interval is always longer. When a 2-1 rhythm has just passed back to the normal the interval lengthens to about $\frac{1}{2}$ of the cycle or even $\frac{1}{3}$, showing that when the ventricles are responding to every stimulus either the conduction is slower or a longer latent period occurs than when only every second stimulus is effective. Within a minute or two of the commencement of normal rhythm the interval again is practically normal. At the commencement of any state of heart-block the $A\text{-}V\text{s}$ interval is long and gradually shortens almost to the normal. A lower state of heart-block then develops with a long interval, which again shortens to nearly normal, and this gives place to a still lower state of block or normal rhythm, also with a long interval to start with, which shortens again up to nearly the normal.

Usually when the $A\text{-}V$ bundle was cut right through, after a few tumultuous contractions caused by the mechanical stimulation, the ventricles would be still for from about eight auricular cycles up to several minutes, when one or two small contractions might occur, after which on many occasions no further systole was recorded for a quarter of an hour—sometimes more, sometimes less. The ventricles then gradually quickened to their own independent rate of about $\frac{1}{2}$ to $\frac{1}{3}$ the auricular rate. At first one ventricular contraction may occur as seldom as every two minutes or more, soon quickening to one to every 8 or 10 auricular systoles, then 1 to 4, or less, as the case may be. The normal ratio of auricle to ventricle in total heart-block is between $3\frac{1}{2}$ and 4 to 1. On one occasion, when the $A\text{-}V$ bundle was completely divided at the first cut, no ventricular systole occurred for an hour and a quarter. In three experiments the ventricles remained relaxed and did not contract spontaneously again, though they continued to respond readily to mechanical or electrical stimulation, while the auricles continued vigorously at their normal rate. This was very unusual and difficult of explanation, unless it be that a still longer time was required for the establishment of the inherent rhythm of the ventricles than was given, though more than an hour was allowed, and in none of these three cases was the block produced at the first cut, so that half an hour should have been more than enough.

In some experiments, after the $A\text{-}V$ had been divided and the ventricles had resumed their own independent rhythm, a reverse conduction developed with an auricular extrasystole following nearly every second ventricular contraction, but with no sign of any ventricular response to the auricular impulses. The auricular rate was 78 per minute and the ventricular 36, so that this was not a true 2-1 rhythm, and the relative sequence of the auricles and the ventricles was constantly varying. Any ventricular systole that did not occur in the auricular refractory period caused an auricular extrasystole. The ratio of the $A\text{-}V\text{s}$ interval to the normal interauricular interval has a distinct relationship to the difference in the lengths of the auricular extrasystole and the normal auricular cycle following, and also to the ratio of the long pause of the auricular extrasystole to the normal interauricular interval. Thus, we find that when $\frac{A\text{-}V\text{s}}{A\text{-}A'\text{s}}$ (taking $A\text{-}A'\text{s}$ as the normal interauricular period) is 0.25 or less, the difference in the height of the beats is 1 mm. or less; and the $\frac{A''\text{-}A'''\text{s}}{A\text{-}A'\text{s}}$ (taking $A''\text{-}A'''\text{s}$ as representing the long auricular extrasystole) is less than 0.1.

Further, that when $\frac{A\text{-}V\text{s}}{A\text{-}A'\text{s}}$ is 0.76 or more, the difference is again 1 mm. or less in height; and that again the

$\frac{A''\text{-}A'''\text{s}}{A\text{-}A'\text{s}}$ is less than 0.1. The maximum difference in the heights of the beats occurs when the $\frac{A\text{-}V\text{s}}{A\text{-}A'\text{s}}$ is about 0.4 or ranging from 0.35 to 0.45. Either above or below this there is a rapid fall in the difference between the heights of the beats, which at its maximum is 4.5 mm. The same holds true of the $\frac{A''\text{-}A'''\text{s}}{A\text{-}A'\text{s}}$, which reaches a maximum of 0.2 when $\frac{A\text{-}V\text{s}}{A\text{-}A'\text{s}}$ equals 0.427, and is 0.15 when $\frac{A\text{-}V\text{s}}{A\text{-}A'\text{s}}$ equals 0.388, 0.18 at 0.455, and 0.16 when the $\frac{A\text{-}V\text{s}}{A\text{-}A'\text{s}}$ is 0.531. Above and below this proportion the ratio is less than 0.15, and diminishes gradually towards either extreme. There is not a regular ratio between the $A\text{-}V\text{s}$ and the $V\text{-}A\text{s}$ intervals, though roughly it may be stated that the shorter the $A\text{-}V\text{s}$ interval the longer will be the time elapsing before the auricle responds to the ventricular contraction, and the longer the $A\text{-}V\text{s}$ the more quickly the auricles will respond to the ventricles. Absolute compensation was not present, but the extrasystole added to the preceding normal auricular systole was about one-third of the cycle shorter than the sum of two normal periods.

Division of all but half of the left ventricle still failed to check entirely this reversed conduction.

Now these were states of complete and lasting heart-block, and yet there was reversed conduction always occurring when the ventricular systole did not fall in the auricular refractory phase. This does not agree with the results obtained by Fredericq and Hering¹—that when block is complete, with independence of the ventricles, spontaneous extrasystoles do not pass from ventricle to auricle; nor with those of Erlanger²—that when heart-block is complete or partial a ventricular extrasystole will never cause an auricular contraction.

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An Address

ON THE

PRESENT POSITION OF THE ASSOCIATION :
THE NEED OF FURTHER LOCAL
ORGANIZATION.

DELIVERED AT THE ANNUAL MEETING OF THE BIRMINGHAM
BRANCH OF THE BRITISH MEDICAL ASSOCIATION.

By F. MARSH, CH. M., F.R.C.S., ETC.,

CONSULTING SURGEON TO THE QUEEN'S HOSPITAL, BIRMINGHAM, ETC.;
PRESIDENT OF THE BRANCH.

[AFTER thanking the members for his election, and referring to the custom of delivering an address on a subject of general interest from a medical, historical, or political point of view, the President said:]

It must be evident to all who take an interest in the work of the Association that its present position is a critical one, and that much depends on the steps taken during the next few months.

The position of the Branch, as a Branch, is also a critical one. By the constitution of 1901 it was shorn of some of its power, and if the new Charter is obtained in its present form it will lose the important and influential place it has hitherto held in the government of the Association.

The present position is one of gradual evolution. The Association was originally constituted as a purely scientific one, and naturally so. Intercommunication on subjects of medical and scientific interest was then the chief need. There were few medical publications; few, if any, medical societies; comparatively few hospitals. The conditions of practice were different. Competition was less severe; patent remedies were few; the day of compressed tablets had not arrived; advertising had not become a fine art; quackery was, perhaps, not quite so rampant.