

A MEDICAL MISADVENTURE—DEATH FROM STERNAL PUNCTURE

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Introduction

DEATH from any cause is regrettable, and that from a preventable one more so. That a simple procedure like sternal puncture may be attended with fatality is very disturbing and calls for a full analysis when this occurs. This paper describes two cases in whom this happened and also suggests an explanation of the mechanism involved in causing the deaths.

Case records

The first case occurred at a military hospital in 1945. On a preliminary examination a diagnosis of kala-azar was made, and as the spleen was only slightly enlarged, it was decided to perform a sternal puncture to confirm the diagnosis. The doctor attempting the puncture was experienced in the procedure, and he was a competent general physician conversant with the problems involved. After novocain infiltration of the soft tissues and the periosteum, a Bole Brothers make of sternal puncture needle was suitably guarded to expose 8 mm. of the pricking end. It may be mentioned here that this needle is guarded by a screw-guard which cannot slip. It was considered at the time, and proved afterwards at autopsy, that the needle as guarded could not pierce the posterior plate of the sternum, under ordinary circumstances; the guard being of the type that cannot slip, the needle could not go beyond the predetermined length. And yet when the needle was pushed in, there was a gasp from the patient who rapidly became shocked, and died within three minutes. Anti-shock measures were adopted without avail though it was not realized at the time that death had occurred from anything but a severe sudden shock; the clinical picture resembled that of pulmonary embolism with which many are familiar.

At autopsy it was found that the posterior plate of sternum had the minutest puncture through which the tip of the needle could just be protruded. Opposite this puncture hole, there was a laceration $\frac{1}{4}$ inch long in the anterior wall of the right ventricle. There was hæmopericardium and death had occurred from pressure on the heart, preventing further action of the organ. With the cadaver lying supine, the end of the needle introduced through the original route could not be made to touch the heart. The autopsy was performed within an hour of death. The other relevant findings were those of an early stage of kala-azar, the parasite being seen in smears taken from the spleen and the serum giving a positive reaction to Chopra's antimony test. Death was decided

to have been due to a traumatic rupture of the heart from the sternal puncture, though a certain amount of uneasiness was felt in view of the fact that it was assumed that the needle could not have touched the heart.

The second case died under similar circumstances in a civil hospital in 1946. The order of events was approximately the same as in the first case. The needle was guarded by a plate and there was a possibility that the guard had slipped. But this was in fact not so; the guard was placed so as to expose 11 mm. of the needle and this was a safe length for the particular patient as considered at the time and also as confirmed at autopsy. The operation was performed by a competent surgeon who, however, had not performed this operation before. Novocain infiltration was used and no sooner had the needle been pushed into the sternum than the patient gasped and became shocked. Death took place in not less than two minutes, perhaps after four minutes. The surgeon had an opportunity of discussing the first case some time ago, and rupture of the heart was at once thought of. The autopsy revealed a laceration $\frac{7}{8}$ inch long in the right ventricle and a hæmopericardium. The other findings were normal except for an aortic incompetence. The operation had been undertaken to study the bone-marrow for anæmia.

In both cases the laceration was larger on the pericardial aspect than on the endocardial, and the measurements are of the pericardial aspect.

Discussion

That two deaths should have occurred in the course of a rather simple surgical procedure and the absence of a satisfactory explanation for these was rather tantalizing. The matter was discussed with several people who were used to the procedure and the best criticism that could be offered was that there was an error in fixing the guards; but this was in fact not so. Even if it was, the happenings would not have been fully explained, for it is known that a puncture of a muscular organ is easily sealed off immediately after the needle is removed; intracardiac injections are not attended with hæmorrhage into the pericardial sac.

A review of the cases made several facts stand out. Firstly, the needle had punctured the posterior plate of the sternum, though to a very minute degree only, in each case. Secondly, as no premedication was used, the patients were rather apprehensive and probably held their breath. Thirdly, death was in each case due to arrest of the heart from continued hæmorrhage into the pericardial sac. Fourthly, the laceration involved the right ventricle and was nearly an inch long. Fifthly, the needle could not have touched the heart under ordinary circumstances. Sixthly and finally, there was no other cause of death found.

The heart is a very muscular organ, constantly stretching and contracting in diastole and systole respectively. That the tension in the heart is increased by holding the breath is an accepted fact of physiology. Holding of the breath causes an increased carbon-dioxide tension in the venous blood and this increased CO₂ tension enhances the extensibility of the cardiac muscle fibre during diastole. A person can by holding his breath, therefore, make his heart a little larger than normal, and a larger heart will tend to come nearer the sternum. This heart will be more stretched than normal. It is easy to visualize how an apprehensive person will, by holding his breath, bring the heart nearer to the posterior surface of the sternum and thus make it more susceptible to possible trauma from even a minute portion of the sternal puncture needle. It is also easy to see that while a contracted heart may throw off a needle, a relaxed heart may not be able to do so; in fact in a relaxed muscle a small prick will be rapidly converted into a tear if behind the relaxed muscle there is some other force. In diastole of the heart while the muscle is relaxed, there is a constantly rising pressure within the heart. Here then were the circumstances that could explain the two deaths. The apprehensive patient holds his breath, renders the heart slightly larger in size and more extensible, brings it nearer the sternum, where it is touched off by the small unsuspected portion of the needle, the rising tension of the heart converts the minute puncture into a laceration, and hæmopericardium follows.

A series of experiments was then conducted by dropping sharp needles weighted near their business ends on to football bladders which were put under varying degrees of tension. A high tension threw off the needles; a very relaxed bladder did not offer the needle any foothold though a mark was sometimes made. A medium pressure was found to be optimal for production of a puncture. If the bladder was kept attached to the pump, and the needle was dropped when the bladder was about two-thirds stretched, a puncture was easily produced, and the pressure of the pump overcoming the elasticity of the bladder, the puncture was made into a rent. Though suggestive, the experiments did not conclusively prove anything, for the same needle similarly weighted and dropped on the bladder under the same optimal tension did not always produce the tear. It was considered necessary to discover some more cogent explanation which, by itself or in conjunction with what has been said above, would explain all the phenomena.

It has been seen that in performing a sternal puncture, the needle is often pushed in by a series of jerky movements rather than by a steady pressure. These jerky movements give rise to two other movements. Firstly, with each jerk, the sternum tends to flatten out and come in

closer contact with the heart, and secondly with each jerk the patient becomes more apprehensive, causing the man to hold his breath and thus setting in motion the mechanism described above whereby the heart is rendered more liable to trauma from the sternal puncture needle. The jerks also damage the soft tissues in front of the sternum and reduce their depth, and allow the needle to go a trifle deeper. There is, thus, an unintentional and unsuspected increase in the range of the needle.

If heavy pressure is used in forcing the needle through the cortical layer of the sternum, there will be further sterno-cardiac approximation. One jerk may not puncture the heart, for the heart may be contracted in systole, but the next very well may, when the heart may be in diastole and by force of circumstances detailed above held pressed behind the sternum with the wall relaxed but the intracardiac pressure rising.

Experiments were then made on cadavers. It was seen that with the force of the jerky movements associated with sternal puncture, the sternum could be pressed down for nearly an inch and the soft tissues could be reduced in depth for up to 4 mm. If the anterior mediastinum which is after all only a potential space is fully obliterated by the heart, and there is an unsuspected increase in the range of the needle, there is nothing to prevent a traumatic rupture of the heart.

There can be little doubt that the two deaths occurred in the above manner, the sequence of events being as follows:—

1. Apprehension caused holding of the breath and this in turn led to stretching of the heart and its approximation to the sternum.
2. Jerky movements caused an unsuspected increase in the range of the needle; they also caused more approximation of the heart to the sternum.
3. The needle, then, unsuspectingly pierced the posterior plate of the sternum and caused a small prick in the apposed heart.
4. The heart having been put on the maximal stretch both by diastole and increased CO₂ tension, the prick rapidly became converted into a laceration by the rising intracardiac pressure.
5. Hæmopericardium followed leading to mechanical arrest of the heart, and to death.

Conclusion

It will be seen that a whole set of conditions has to be fulfilled before the catastrophe can occur in the above manner. It is not unlikely that this does not happen so very often, and may explain why there are so few deaths in attempting this operation. This, if true, is indeed a fortunate coincidence seeing how very casually sternal puncture is generally under-

taken. The lessons taught, in any case, should not be ignored. They are :—

1. Apprehension in the patient should be forestalled by suitable premedication.
2. The adjustment of the needle should be checked just before the operation. In doubt it should be guarded too much rather than too little.
3. Only the minimum amount of force should be applied and that in a steady pressure, and not in jerks; in fact, great gentleness should be used.
4. The anatomy of the regions affected should be visualized before the operation, and the dangerous nature of this apparently simple procedure remembered.
5. The routine for performing the operation should be standardized and converted into a ritual, as other pre-operative measures have been. The adherence to a strictly followed routine renders mistakes easy of detection.

Summary

1. Two cases are described in which death occurred after sternal puncture.
2. Death was in both cases due to a rupture of the right ventricle following a prick by the needle, causing hæmopericardium and arrest of the heart.
3. The possible mechanism leading to the rupture is discussed and results of certain experiments made in this connection are mentioned.

4. Certain precautions are suggested to prevent such catastrophes.

Note.—The production of a laceration of the heart by the contracting heart itself rubbing against a protruding needle presupposes too much penetration by the needle, and is to be explained by carelessness, and does not form part of this paper, which merely tries to point out some hitherto unrecognized dangers of sternal puncture.

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ARTHRODESIS OF SHOULDER

A CASE REPORT

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ARTHRODESIS of the shoulder from above has been performed for many years, with parts of the acromion process and the clavicle as grafts attached to the upper end of humerus. This technique ignored the fact that the shoulder tends to adduct through gravity and slight adduction may separate the graft with chances of failure of fusion. Brittain recently pointed out that it is not enough that the graft should have an adequate bed and that it is well secured but that the graft should be placed with its long

axis in compression rather than in tension. He applied the architectural principle of a lamp hanging from a wall by a bracket and supported by a stay. If the stay is an underlying one it is in compression and consequently the two ends of the stay tend to become secure, whereas if the stay is an overlying one, there is tendency of separation of the two ends of the stay due to gravity [*vide* figure 1 (a) and (b)].

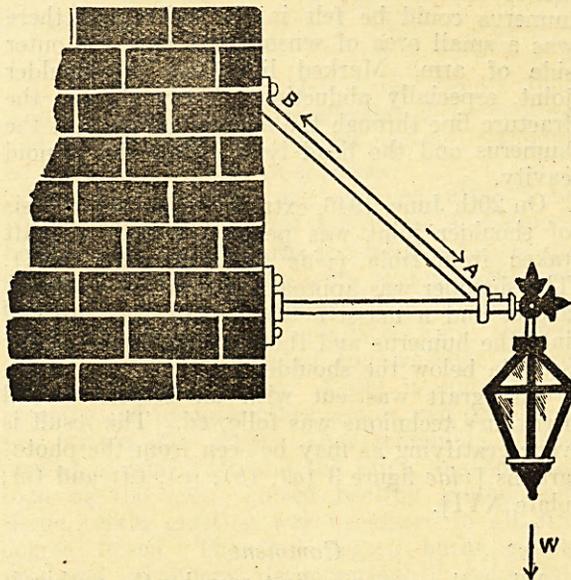


Fig. 1.—(a) Showing position of the stay under tension. Lamp hanging from a wall by a bracket and supported by an overlying stay. The stay is in tension, and there is tendency to disruption at points A and B. (After Brittain.)

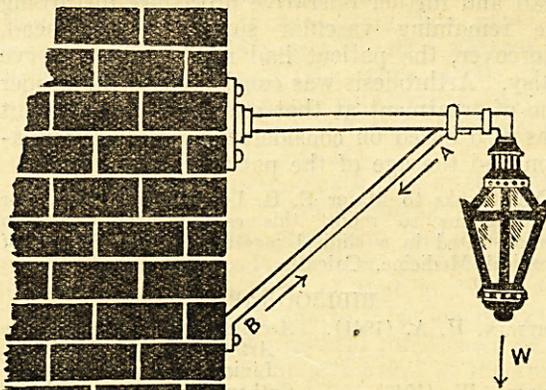


Fig. 1.—(b) Showing the position of the stay in compression. An ideal position for the bone graft. Lamp hanging from a wall by a bracket and supported by an underlying stay. The stay is in compression. Consequently points A and B are tending to become more secure. (After Brittain.)

In other words if the graft is placed below the scapulo-humeral joint, there is every possibility of the graft taking, thus leading to a sound arthrodesis.