decreasing sharply from thirteen to fourteen horizontal items; this might possibly correspond to the type of short incubations mentioned in the literature, but the series, although a long one, is hardly long enough for the isolation of periods by the summation method to be quite satisfactory unless the change of oscillation is much more considerable than has been found to be the case. A second process which is readily applicable to astronomical data, for which the periodogram method is largely used—viz., subtraction of the ascertained periodic constituent (here the eighteen days’ period) from the series in order to see how far the observations are reproduced—i.e., how little remains unaccounted for—fails because the epidemic is evidently declining in intensity, so that a simple sine series could not be used. I am not confident, therefore, that any other period than the one of eighteen days exists.

Reverting to the second suggestion of external disturbing factors, it is to be noted that during the last week in February the disease was introduced for the first time into a very susceptible rural battalion with the result that an exceedingly large number of cases developed eighteen days later, all the susceptible men in the battalion apparently contracting the disease as the result of contact with the first cases to appear. There were other disturbing elements such as susceptible men being brought into the area from time to time, and also concealment of the disease during week ends and holidays.

The chief point brought out is the existence of an eighteen days’ cycle as a chief component of the epidemic. Assuming this to represent a phase of the life cycle of the causative organism, it is seen to be maintained through several generations.

I wish to thank Major M. Greenwood, R.A.M.C., for the interest he has taken in this note, and for his valuable assistance in looking up the literature and affording me several references.

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A CASE OF REMOVAL OF A RIFLE BULLET FROM THE RIGHT VENTRICLE OF THE HEART.

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AND

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Trpr. M., aged 21, was wounded by a bullet on November 14, 1917. He rode some miles to the nearest dressing station and then collapsed. On examination it was found that the bullet had passed through the upper part of the right arm behind the humerus, and then entered the right chest between the fourth and

The decline of the epidemic might be thought to support the belief that cold and changeable weather is a factor of epidemic prevalence, a view countenanced by the father of medicine, Hippocrates, who described undoubted mumps as epidemic in Thasos at the beginning of spring ("Epidemics," Book I, Chap. 1), and partly by Hirsch (op. cit., p. 281).

I could trace, however, no connection between the weather and the course of the epidemic, while summer outbreaks have often been recorded (e.g., by Calmette, Arch. de Gen. Medecine, 1889, p. 455, in troops at Brest between May, 1877, and April, 1878).
Fig. 1.—Radiogram of position of bullet.

To illustrate "A Case of Removal of a Rifle Bullet from the Right Ventricle of the Heart,"
by Dr. Marguerite White and Colonel Sir Charles Ballance, K.C.M.G., A.M.S.
fifth ribs and had not emerged. A radiogram taken the next day showed the bullet two inches from the surface in the cardiac region on a level with the inferior border of the heart; the bullet moved with the cardiac pulsations. It was thought to be in the wall of the left ventricle near the anterior margin. There was some fluid at the base of the right pleura.

November 16, 1917.—Operation at the 40th Casualty Clearing Station Hospital, Salonika. Transverse incision through upper part of left rectus and exploration of under surface of diaphragm. Nothing abnormal found.

![Diagram of bullet position](https://example.com/diagram.png)

Patient was transferred to 63rd General Hospital, Salonika. The abdominal wound was then suppurating. Examination of chest. No pericardial rub. No definite cardiac murmur, small amount of fluid at base of right chest. Left lung normal. X-ray examination confirmed previous report. Bullet still thought to be in left ventricle.

Patient admitted to St. Elmo Hospital, Malta, from Salonika on January 13, 1918, as a cot case.

On Admission.—General condition good. While lying down pulse 96 steady and regular; on exertion, such as getting out of bed or picking up an object off
the floor from the bed, the pulse became irregular and rapid. He was once allowed to cross the ward, when the pulse rose to 130 and the face became pale. The other clinical findings were all negative except for a small goitre which had been present for years. The patient came from Derbyshire. Repeated X-ray examinations, both with the screen and by means of stereoscopic plates were made, with the assistance of Major Campbell, R.A.M.C. (fig. 1). These showed movement of diaphragm independent of the bullet. The bullet lay behind the left fifth cartilage and left fifth intercostal space, \( \frac{3}{4} \) inch from the left border of the sternum and about two inches deep from the skin surface in front. The base of the bullet lay towards the right while the pointed end was directed towards the left and somewhat downwards, and moved more than the base with the pulsations of the heart. It was thought that the base of the bullet was fixed in the wall of the right ventricle and that the pointed end was in the cavity of the right ventricle (fig. 2).

**Decision to Operate.**—The patient had suffered severely from sea-sickness during the voyage from Salonika and this had caused much distress from palpitation and choking sensations. Further, the rapidity and irregularity of the heart on the slightest exertion and the known position of the bullet made it desirable to perform an exploratory operation in order to determine whether it was possible to remove the bullet. The patient had remained in bed under observation without improvement.

**Operation, February 16, 1918.**—Lieutenant-Colonel Shirley gave the anaesthetic. Kocher's incision for exposure of the heart was made and the fourth, fifth and sixth costal cartilages of the left side were removed. The internal mammary artery was tied in two places and divided between the ligatures. The triangularis sterni was divided and the border of the left pleura crossing obliquely the front of the pericardium was seen and thereafter held aside with a copper retractor. No injury to the pleura occurred. The anterior surface of the pericardium appeared normal except for a small puckered scar \( \frac{1}{4} \) inch from the left border of the sternum about the level of the fourth space. An incision was made in the pericardium passing obliquely downwards and towards the left and as long as the resection of the chest wall allowed. A very little gas and frothy fluid escaped but no adhesions between the parietal and viscerat layer of the pericardium were found. The anterior surface of the heart appeared normal both to sight and touch. One of us (W.) then palpated the posterior surface of the heart and at once felt the bullet through the wall of the right ventricle near the apex. Five stitches of No. 1 silk were then passed close to the apex of the heart along the anterior inter-ventricular groove. Near the apex the groove was somewhat obscured by fat and the stitches passed through both muscle and fat. These threads were used to pull the apex of the heart forwards and upwards; a first-rate exposure of the posterior surface was thus obtained. On the posterior aspect of the heart no scar was visible and no bulging was seen. Palpation determined that the bullet was lying near the apex of the heart on the right side of the posterior inter-ventricular groove and was apparently in the ventricle. Four silk stitches were next inserted in the wall of the right ventricle along the line of the proposed incision; they passed twice through the muscle so that the loop could be drawn out of the way while the incision was being made. One of us (B.) then seized the heart with the left hand, using the thumb to compress the
right ventricle above the line of the proposed incision. It was found difficult to cut the quickly contracting heart muscle with the knife, so the incision into the ventricle was completed with scissors. B. then introduced a pair of artery forceps into the cavity of the right ventricle through the incision, seized the free extremity of the bullet and pulled it outside the heart. In doing so the inner surface of the ventricular wall was everted, exposing the columnae carneae, because the base of the bullet was firmly embedded and attached to this surface. W. then with a knife cut the inner aspect of the ventricular wall and the bullet was free. The haemorrhage was fairly profuse but was at once controlled by pulling on the stitches which had already been passed, and by putting in four more so as to invert, Lembert-like, the outer wall of the ventricle. The manipulation at no time affected the work of the heart, and the pulse only failed momentarily when blood was escaping from the heart. There was no visible sign of inflammation or sepsis. The pericardium was filled with saline and stitched up. The superficial incision was also closed and the patient returned to bed without shock. Colour good, respiration 20, pulse 110. Throughout the operation the blood-pressure was carefully noted.

Fig. 8a.—Photograph of front view of parts removed at the autopsy. Below is seen the heart and pericardium. A portion of skin surrounding the wound has been left in situ. Above is seen the abscess cavity in the right lobe of the thyroid gland.
Course of the Case.—For three days the condition was encouraging. On the fourth day some emphysema was noted on the upper part of the left side of the gladiolus and in the afternoon of that day there was serious collapse, from which the patient rallied after strychnia and oxygen had been given and mustard baths applied to the extremities. That night he was very restless, complained of pain in the chest, and had an irritating cough with choking sensations. Next day (February 21) while coughing, a large quantity of clear fluid of a yellow colour, and somewhat sticky and albuminous, escaped from the wound. He became unconscious and pulseless; strychnia and oxygen were again given, ether injected subcutaneously and mustard baths applied to the extremities. The patient revived, and in half an hour asked for his breakfast. Pulse 90, strong and regular. Breathing deep and easy, all pain gone. Profuse drainage from wound. On February 24 the discharge from the wound was definitely purulent, the skin flap was opened up, and the next day all stitches in the pericardium were removed, and the pericardial cavity, which contained pus, was irrigated with saline solution.

![Figure 3b. Photograph of front view of parts removed at autopsy. Same as fig. 3a, but enlarged, and not showing thyroid gland.](http://militaryhealth.bmj.com/.../1918. Downloaded from http://militaryhealth.bmj.com/.../1918.)
The subsequent history is that of progressive sepsis, with free discharge from the wound, and although the patient was carefully tended and was twice transfused, he died on March 14.

**Autopsy.**—Wide gaping wound in precordial region; large opening in pericardium; considerable area of anterior aspect of heart exposed. Petechial hemorrhages subcutaneously and over some of the viscera. Liver, nutmeg mottling on sections. Spleen, somewhat enlarged. Kidneys, numerous minute abscesses and cloudy swelling of cortex. The thoracic viscera were taken away entire and preserved in ten per cent formalin for further examination. After

**Fig. 4.**—Posterior view of intrathoracic thyroid lobe, and above is seen the abscess cavity. Below the tissue is solid with some cysts of small size.

fixation: Both lungs normal. No enlarged glands in hilum of either lung or in mediastinum; the latter was normal. Esophagus, trachea and main bronchi normal. The right lobe of the thyroid extended downwards some distance, indeed to the bifurcation of the trachea. This enlargement and extension downwards of the right lobe of the thyroid pressed the trachea towards the left, giving it a definite curve in that direction. At the back of the right lobe of the thyroid was a cyst 1½ inches in diameter containing pus, below the cyst was more thyroid tissue which extended to the bifurcation of the trachea. The thoracic lobe was 2½ inches long by 1½ inches wide and was circular on horizontal section. On
section numerous cysts were seen, many of which contained pus. In parts the interstitial tissue contained calcareous matter.

The pericardium was opened from behind, it was lined by a thick adventitious membrane, the visceral layer was everywhere intact but thickened, and some petechial hemorrhages were seen. The line of incision at the back of the right ventricle was not visible but two or three puckers on the surface of the heart gave some indication of the site of operation. The operation incision had to the

![Fig. 5. — Posterior view of heart showing the healed line of incision. This is indicated by the projecting ends of some of the sutures.](image)

naked eye apparently healed. Microscopic sections through site of incision in ventricular wall showed the line of incision occupied by young connective tissue and evidence of pus at the surface; other sections showed encapsulation of ligature and changes in the cardiac muscle near the incision.

**Note by Professor S. G. Shattock, F.R.S., on the Microscopic Sections.**

In the myocardium about the line of incision there is a well-pronounced formation of fibroblastic tissue which in some spots appear to have united certain of the muscular fasciculi, and in others not.

In the neighbourhood and in the line of the injury there is a somewhat widespread fibrino-purulent exudate containing several colonies of staphylococcus.

It may be observed that secondary hemorrhage would have been likely to take place if the patient had lived longer, as the wound was so imperfectly healed and so acutely infected.
Remarks.—We have in the first place to express our thanks to Colonel Sir Archibald Garrod for the constant help he gave us in the management of the case. With regard to the course of the bullet the scar on the front of the pericardium and the fact that the bullet was deformed and must have been spent, make it probable that it passed forwards and downwards through the right chest, struck the back of the gladiolus and was thus deflected backwards through the pericardium and into the heart. We are publishing the case in full for the sake of those who, in the future, may have to operate on bullet wounds of the heart. Looking back upon the case we think it would have been pure luck if recovery had ensued and thus some other surgeon reading a glorified account of the case might have followed our methods and met with disaster. While the operation was carried out in many respects on the ordinary principles of surgery, treating the heart muscle like any other tissue of the body, the after-treatment was not in its early stages so conducted. When the patient became ill, instead of treating the case on ordinary principles and opening the lines of incision, we were absorbed in dreams and idle speculations, one of which was that clot was forming on the wound in the interior of the right ventricle and that its extension was embarrassing the action of the heart. It is a common experience that bullets frequently lodge in the tissues and induce neither local nor general infection until attempts at removal are made. The total absence of adhesions or any visible sign of inflammation in the pericardium and heart led us to close the wound in the pericardium, which was a fatal mistake. Further, on opening the pericardium we had observed a little gas and frothy fluid which notwithstanding all the other appearances must have been pathological, so that looking back we may affirm that there was no valid excuse for closing the pericardium. We were so little experienced in viewing large areas of the living heart that we had an instinctive desire to close the wound quickly and get it out of sight as soon as possible. As a matter of fact the pericardium and superficial wound should have been left widely open as if the operation had been done for suppurative pericarditis. The question of possible sepsis was ignored and further, in order not to leave any air in the pericardium, which might have caused surgical emphysema, it was filled to the brim with normal saline solution, and we believe that this must have embarrassed the heart and promoted sepsis, for though no absorption took place we are convinced that the amount of fluid was considerably increased by secretion. We do not know the normal amount of fluid in the pericardium in health, but we do know that it was a mistake to distend the pericardium with fluid, especially as we were in total ignorance of the absorbing power of the pericardium. We fancy that none of the fluid introduced was absorbed, and that being under pressure it was one of the prime factors in the early stages of the septic process. When the patient became ill on the fourth and fifth days and we were anxious about him, though the temperature was not above 99° F., there was no bulging forwards of the pericardium under the skin flap. This rather led the mind away from the pericardium to possible other causes of the condition. It was forgotten that the pericardium is an inelastic white fibrous membrane and could not possibly bulge forwards beyond its anatomical limits. The appearances during operation were so apparently normal that the bullet on removal was not, as it should have been, dropped into a culture medium. In the course of the case it appeared reasonable to assume that an abscess might form in the posterior mediastinum. The
lymphatics of the pericardium we believe go to the bronchial lymph glands, but we could not obtain a modern book of reference, such as Porier and Charpy, or Testut, on Anatomy. The Rector of the University, Professor Magro, kindly gave us a cadaver to practise the operation of opening the posterior mediastinum. We

found that the removal of about two inches of the sixth and seventh ribs commencing two inches from the spines of the vertebrae enabled us to reflect the parietal pleura without injury or difficulty and to enter the mediastinum. In this body the posterior surface of the pericardium was five inches from the skin surface of the back.

Various types of bullets, showing which are and which are not magnetic.

Bullet (deformed and enlarged).

FIG. 6.
Before operation we obtained bullets of different nations to see whether a magnet would be useful in removing the bullet from the patient. It was probable, indeed certain, that the bullet lodged in the patient was projected from a Bulgarian rifle as the only prisoners taken in the action in which this soldier was wounded were Bulgarians. The modern Bulgarian bullet tested by us was not magnetic, while the modern Serbian bullet proved strongly magnetic. We therefore did not have in the theatre the powerful electro-magnet made for us by the Royal Engineers. After removal the bullet proved to be an old Bulgarian bullet and was strongly magnetic (fig. 6).

Seeing that the patient had a goitre we ought to have studied this tumour by radiography before doing the heart operation. It would then have been discovered that there was an intra-thoracic lobe, and it might have been decided to remove this before operating on the heart. The cavity of this lobe might have been recognized, and the displacement of the trachea would certainly have been ascertained by an X-ray examination. The question also arises, was pus present in the thyroid before operation, and if not what is the lymphatic connexion between the pericardium and the thyroid gland?

It was impossible to drain the pericardium by placing the patient in the prone position as the heart then immediately blocked the exit from that cavity. At one time we thought that an abscess was forming in the posterior mediastinum, because of intermittent discharge of pus from the left side of the posterior part of the cavity; this portion being inaccessible to visual examination we could not judge what was going on there, as we could in all other regions of the pericardium. We, indeed, almost hoped that an empyema would form in the left pleura, because then it would have been possible to drain the empyema and at the same time to make an incision in the pericardium far back on the left side. We were familiar with a case of suppurative pericarditis in which this operation was done, and the patient recovered. But in this heart case no empyema occurred and no extension to the mediastinum; indeed, the thick strong wall of the pericardium could not easily or quickly give way to softening or perforation by the action of pus. We may mention that vaccines were used, but were of no avail. The use of a small soft rubber catheter with its point behind the heart, for continuous irrigation of the pericardium, caused no disturbance of the heart's action. In Kocher's operation the cartilages are divided at their inner extremities and displaced outwards with the flap. This seemed undesirable, and a less simple procedure than removal, hence in this case the cartilages were taken away. During the War several cases have been recorded of operations on the heart, in the Daily Review of the Foreign Press, and elsewhere. The difficulty of dealing with suppurative pericarditis is emphasized in the story of these cases. Other instances in which operation has been done are recorded, but the final result has not been stated. We think, therefore, that the publication of a fairly full account of this case may be useful to our fellow-workers.

**Abstract of the Daily Notes of the Case.**

*February 16, 1918.—Operation.*

*February 17.—Patient vomited for twenty-four hours after the operation; somewhat restless; was given morphia and strophanthus; temperature 98·6° F.; pulse 110, good quality.*
February 18.—No sickness; slept all night; very comfortable; pulse 120, rather high tension; temperature normal; heroin and strophanthus, two doses given during the day; taking nourishment well.

February 19.—Slept all night; pulse 138, soft, missing one every six beats; taking nourishment well; temperature normal.

February 20.—Slept well; pulse 128, missing one every third beat; respiration 24; colour good; patient apparently very well; doubtful extension of pericardial dullness to right; some emphysema on upper part of left side of gladiolus. 12 noon: Temperature 100° F.; pulse 120; breathing laboured and shallow; extremities cold; perspiring profusely; very thirsty. 3 p.m.: Temperature 98° F.; pain in left side of chest and very restless. 5 p.m.: Serious collapse; face and limbs cyanotic; no radial pulse; strychnia and oxygen given and mustard baths to the extremities. 7 p.m.: Patient much better; good colour; pulse 120; temperature 99° F.; respiration 38; heroin and strophanthus given.

February 21.—Very restless night; temperature 99° F.; pulse very feeble; breathing difficult; pain in left side of chest; irritating cough and choking sensations. 11 a.m.: While coughing a large quantity of clear fluid of a yellow colour and somewhat sticky and albuminous in character escaped from the wound; patient became unconscious and pulseless; strychnia, oxygen, ether subcutaneously, hot mustard baths to the extremities revived the patient; in half an hour patient asked for his breakfast; pulse 90, strong and regular; breathing deep and easy, all pain gone; profuse drainage from wound. 3 p.m.: Has slept three hours; is very comfortable; blood-pressure 120.

February 22.—Temperature 101° F.; pulse 90, good volume and regular; taking food well. Morphia ½ grain given in evening.

February 23.—Wound draining considerable quantities of clear serous fluid; temperature 101° to 102° F.; eusol compresses; some of the superficial stitches removed.

February 24.—Temperature 102° F.; pulse 120; respiration 30 to 40 when awake, 24 when asleep. Some more stitches removed; fluid turbid, very free drainage. 7 p.m.: Some pus coming from wound; skin flap opened up, exposing a gangrenous cellulitis beneath; irrigation with eusol. There is no obvious opening in the pericardium—the incision seemed closed entirely; eusol pack to wound; this was frequently changed.

February 25.—9 a.m.: Temperature 100·8° F.; pulse 120, regular. There is now an opening in the pericardium; through this opening thin purulent fluid in pericardium was washed out by means of a catheter and eusol. 3 p.m.: All the pericardial stitches were removed, and the whole length of the line of incision in this membrane was opened and the cavity irrigated with saline solution. 9 p.m.: Temperature 101° F.; pulse 130, irregular; respiration 40, when asleep 26.

February 26.—Has had a very restless night, with pain in chest and feeling of faintness. Temperature 100·2° F.; pulse 112; respiration 34. 9 p.m.: Pulse irregular and rapid; has been given morphia and strophanthus. Pericardium washed out every eight hours by pouring a jugful of eusol slowly into the pericardium.

February 28.—Not so well; breathing shallow; complains of fullness in the chest; diarrhoea; pulse rapid and irregular; much pus coming from pericardium,
especially from left posterior region which could not come under observation like other parts of the cavity.

March 1.—9 a.m.: Left chest normal, right chest dull behind up to level of fifth rib. Temperature 104°F.; pulse 128; respiration 38. Query—Empyema on right side from continuity of infection from pericardium; right chest exploratory puncture, clear fluid removed which proved sterile. The examination of the pericardial pus showed the presence of *Streptococcus pyogenes*, *Staphylococcus aureus* and a long thin bacillus which was gas producing and which Major Russell could not identify. Blood films negative to malaria.

March 2.—Temperature 104°F.; pulse 128; breathing better; oedema of left foot; the pus from the pericardium is less in quantity and the question arose, was it escaping into the mediastinum?

March 3.—Patient's condition unchanged. Right chest aspirated, twelve ounces of clear fluid removed which proved sterile; temperature still 104°F.

March 4.—The temperature dropped to 101°F. in the evening, respiration 24; wound outside pericardium quite healthy; complains of bad taste in the mouth; dyspnœa, dysphagia, and pains on left side of chest.

March 5.—Leucocytes count 4,500; temperature during night dropped suddenly to 97°F from 104°F.; patient much collapsed; much pus suddenly escaped from pericardium, probably a local collection behind the heart; incontinence of faeces and urine. 9 p.m.: Temperature 100°F.; pulse 120; taking food well; dyspnœa and dysphagia absent.

March 6.—In the effort to check the sepsis it was decided to do direct transfusion of blood. Major Russell had previously selected a donor whose blood was homologous to that of the patient; patient looks very anaemic and is very feeble; temperature 100°F.; pulse uncountable and irregular. While the donor's artery was being anæsthesized with eucaine he fainted, the blood-pressure fell to 90 and the transfusion of blood became impossible. The patient was then infused with Oii of normal saline to which was added 3iii of brandy and six cubic centimetres of a 1 in 1,000 perchloride of mercury solution.

March 7.—Very good night; pulse still irregular, volume better; taking nourishment well. 9 p.m.: Saline infusion repeated with 3iii of brandy and seven cubic centimetres of 1 in 1,000 solution of perchloride of mercury. There is phlebitis of external saphenous vein of left leg.

March 8.—Urine shows for the first time albumin, casts and pus; autogenous vaccine given. General condition slightly improved. Temperature 100°F.; pulse 100.

March 9.—Temperature 102·6°F.; pulse 96, regular; sweating a good deal; taking food well. Large quantity of pus coming from pericardium, the amount of pus seems stationary; the cavity is still irrigated every eight hours with eusol.

March 10.—Patient very anaemic and weak; petechial cutaneous haemorrhage at various places. Temperature 101°F.; pulse 120. Blood transfusion decided on; haemoglobin, fifty-eight per cent; leucocyte count, 4,500. 8 p.m.: The transfusion apparatus of Bazett was employed. On dissecting out the radial artery of the donor it was found extraordinarily small—it was obvious that the radial artery had divided higher up the forearm. The operation was, however, continued; but the stream of blood from the small artery of the donor was
unsatisfactory, and it was thought that not more than 300 cubic centimetres had passed into the vein of the patient; nevertheless, the colour of the patient improved and the pulse dropped from 130 to 90.

March 11.—Leucocyte count, 12,700; haemoglobin, sixty-eight per cent. Thus a marked improvement in the condition of the blood was effected by yesterday's transfusion. Patient very weak and feeble, but colour better. Temperature 99° to 101° F.; pulse varies from 90 to 120. Much pus from pericardium; continuous irrigation with eusol. Strychnine and digitalis every three hours; glucose ½ v, brandy ½ i, every four hours per rectum.

The patient's condition remained very grave till his death on March 14. Another transfusion of blood was carried out on March 12: a large quantity of blood passed from the donor to the patient; the operation was continued till the blood-pressure of the donor fell to 90. Blood was passing from the donor for 5½ minutes. The red count previous to the transfusion was 1,500,000. Major Russell estimated next day that two out of every three red blood corpuscles in the patient's blood had come from the donor. The last two days the temperature was normal or 99° F., and consciousness was present to the last.