Extension is applied to the leg and the limb suspended, on a bent Thomas knee splint, by 4-in. rubber slings. The back of the knee-joint is supported on a bent perforated zinc splint reinforced by aluminium strips, which is, in turn, suspended from the Thomas splint by rubber

Thomas splint adapted for excision of knee.

tubes above and below. The knee-joint is thus firmly supported in a slightly flexed position under extension, and moreover, in spite of continuous drainage and frequent dressings, the limb can be kept dry and comfortable.

The bed is so arranged that the discharge drains into a bucket placed below it. The wound dressings are kept moist by hypertonic saline solution being sprayed on them, and thus the bandage never acts as a plug.

The dressing is removed when indicated, a general anaesthetic being given, and a similar dressing applied.

Later, this dressing may be replaced by one of eusol irrigation twice daily.

This treatment is continued until the wound is clean. We then, under a general anaesthetic, remove the articular cartilage from the ends of the undamaged bone. The flap formed by the patella and superficial tissues, which has up till now been kept under extension, as previously described, is sutured in position, plates of aluminium being employed to give equal tension and prevent the sutures cutting through.

A thin piece of rubber is left in the posterior part of the wound to act as a drain.

Finally, the limb is put up straight on the Thomas splint with a ham splint posteriorly to support the knee.

CASE VI.

Pte. M., wounded by shell fragment on June 2nd, 1916. Admitted June 4th, 1916. The patient had a large lacerated wound on the inner side of the left knee-joint, with a smaller wound on outer side of thigh about four inches above the condyle. Wound very foul, with free discharge of pus and synovial fluid. Temperature 99°, pulse 108. Skiagraph showed a comminuted fracture of the internal condyle of the femur.

On June 5th, under an anaesthetic, wound edges trimmed and loose portions removed. The wound on outer side of thigh appeared to be the entrance wound, the projectile passing between the large vessels and the bone. Fluid taken from the joint, which the pathologist reported to contain enterococcus and streptococcus.

On June 7th temperature 102°, pulse 110; joint painful. Free discharge of pus from the wound.

On June 8th, under an anaesthetic, joint opened up by anterior incision. The interior severely infected, and in a sloughing condition. Internal condyle extensively comminuted. Both semilunar cartilages removed and crucial ligaments divided, the lower ends of the femur then excised immediately above the condyles. All tags of synovial membrane and sloughing tissues removed. The limb was fixed in a flexed position on a Thomas knee splint, the wound packed with salt bags, and patella flap extended.

June 12th. The wound had discharged freely for the past three days. Temperature 99°, pulse 110. Dressing changed under an anaesthetic, wound cleaning up well and sloughs beginning to separate. The patient has a bromide mixture, with morphine when necessary.

June 16th. Wound dressed without anaesthetic. The dressing came away easily with little pain. Eusol irrigations twice daily, with light eusol dressings substituted for salt pack. Temperature 99°, pulse 90. Little pain.

June 23rd. Wound almost clean, and covered with healthy granulations. Under an anaesthetic the articular cartilages on the head of the tibia were removed and the spine chiselled away. The patella flap was sutured in position, aluminium plates being employed. A thin rubber drain was left in the posterior parts of the joint. The limb was put up straight on a ham splint, suspended in a Thomas splint. The wound healed well, and when evacuated to England on July 9th there was only a small sinus discharging on the internal aspect of the joint.

The foregoing is a summary of a wide subject, and one which we venture to think has not as yet received the attention it merits. We hope that this short article may prove an incentive to others to make known their views.

Owing to the present stress of work we apologize for the somewhat crude method in which the subject has been presented.

THE USE OF ATROPINE AS AN AID TO THE DIAGNOSIS OF TYPHOID AND PARATYPHOID A AND B INFECTIONS.

(Preliminary Note.)

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DURING the past year I have studied and recorded graphically the various cardiac irregularities met with in typhoid and paratyphoid fevers. In the course of this investigation, carried out on lines advocated by Sir James Mackenzie, I

was led to devote special attention to the relatively slow heart-rate which commonly occurs in this group of fevers. It is well known that atropine increases the rate of the heart by some twenty to forty beats per minute. I found that the rate of a slowly beating heart in each of these fevers was

hardly accelerated at all by the injection of $\frac{1}{3}$ grain of atropine sulphate hypodermically.

Further observations showed me that in practically all

cases of the typhoid group during some period of the infection the rate of the heart could not be increased by atropine as the rate can be accelerated in normal people and those suffering from other diseases. As I found that the failure of the heart to respond to atropine was so constant in all cases bacteriologically proved to belong to the typhoid group I began to use this reaction as a means of diagnosis.

The whole of the work on this subject was carried out at a stationary hospital (under command of Lieutenant-Colonel C. R. Evans, D.S.O., R.A.M.C.) which is specially equipped for typhoid cases and possesses a full bacteriological laboratory, where, in addition to the ordinary routine of examination by cultures, Professor Dreyer's

method of diagnosis by agglutination has been employed under his personal advice, and used to control all the cases enumerated in this paper.

Method of Making the Test.

At least one hour after a meal should elapse. The patient should lie horizontally and be instructed to keep

perfectly quiet throughout. The pulse-rate is then taken and recorded minute by minute until found to be steady. Usually ten minutes will be found to suffice for this;

CHART I.—Effect of hypodermic injection of $\frac{1}{3}$ gr. of atropine sulphate (A) upon the pulse-rate of a healthy man aged 24 who was bacteriologically and serologically shown to be free from typhoid, paratyphoid A, or paratyphoid B infections. (Mackenzie polygraph.)

then $\frac{1}{3}$ grain atropine sulphate is injected hypodermically, preferably in the triceps region to ensure rapid absorption. The patient now remains absolutely quiet, and, after an

CHART II.—Effect of hypodermic injection of $\frac{1}{3}$ gr. of atropine sulphate (A) upon the pulse-rate in a bacteriologically proved case of paratyphoid B infection (bacillus isolated from stools serologically positive to paratyphoid B infection) on the twelfth day of disease. Temperature 102.5°. (Mackenzie polygraph.)

interval of twenty-five minutes, the pulse-rate is again taken and recorded minute by minute until it is obvious that any rise which may have followed the injection of atropine has passed, and that the rate is falling to a lower level—fifteen to twenty minutes may be necessary. An actual reading would be as follows:

Before atropine:

Pulse-rate ten consecutive minutes—

72 70 68 69 67 68 68 67 69 68.

After atropine:

Twenty-five minutes later—

89 90 92 91 94 95 94 92 90 96 (coughed)
90 89 88 87 88 86 stop.

The mean value of the pulse-rate in the first series of observations is judged to be 68. In the second series the pulse-rate is rising and falling on a curve similar to that shown in Chart I. The aim is to choose that rate which lies along the top of the curve. Excluding incidental changes due to muscular movements, coughing, and so on, the mean highest value in this series would be judged to be 94. The difference between the pulse-rate before and after atropine is in this case 26 beats a minute.

CHART III.—Case of true typhoid. Fully inoculated, six months previously, against typhoid only. *B. typhosus* isolated from stools, positive to agglutinations. A = Atropine $\frac{1}{3}$ gr.

As an arbitrary rule, an increase of the pulse-rate by about 20 or more beats a minute after atropine may be accepted as an indication that the patient is probably not suffering from typhoid or one of the paratyphoid series. Should the pulse-rate increase only 10 beats or less the reaction is suggestive of an infection by one of these diseases. Readings which give a difference of more than 10 and less than 20 beats a minute are uncertain in their interpretation, and necessitate further observations a day or so later.

The curve in Chart I represents a continuous series of pulse observations made on a healthy man before and after the injection of the test dose of atropine. The actual figures are those given in the preceding table. The man had been fully inoculated against typhoid four months previously. It will be noted that immediately after the injection of the atropine there was a fall in pulse-rate for a few minutes, then a rapid and marked acceleration, which gradually fell away some thirty minutes after the injection of the drug, and reached the base line about one hour and twenty minutes later.

In Chart II we see the effect of $\frac{1}{3}$ grain of atropine in a bacteriologically proved case of true paratyphoid B. The patient had been fully inoculated against typhoid only in October, 1914, some eighteen months previously. After the injection of the atropine there is to be noted a gradual fall in pulse-rate and subsequent gradual slight increase in rate, reaching a maximum after thirty-five minutes, and regaining a base line an hour or so later. In some cases the slowing is so marked that the pulse-rate does not regain the initial rate after one and a half hour's observation, so that the atropine has actually caused persistent slowing of the heart.

A study of these two curves will show that from a practical point of view the period of twenty-five minutes immediately following the injection may be neglected, as the "highest mean rate" is generally attained near the end of the first half-hour.

In the accompanying charts are shown the effects of atropine upon the rate of the pulse on various days

CHART IV.—Case of paratyphoid B. Fully inoculated, five months previously, against typhoid and paratyphoid A and B. Bacillus isolated from stools; agglutinations positive to *B. paratyphosus* B. A = Atropine $\frac{1}{3}$ gr.

throughout the disease, in bacteriologically proved cases of true typhoid (Chart III), paratyphoid B (Chart IV), and paratyphoid A (Chart V), occurring in inoculated men; and of true typhoid in an uninoculated man (Chart VI).

Explanation of Charts.

In the charts the numerals to the left of temperature figures denote the pulse-rate, ten corresponding to the interval between each degree of temperature. The thick dark bands denote the effect of the injection of atropine upon the pulse-rate, on days shown, the lower end corresponding with the average rate before the atropine, the upper end to the mean highest rate reached after the atropine. The length of these dark bands consequently indicates the extent of "escape" on acceleration.

Case of True Typhoid in an Inoculated Man.

In this case (Chart III) on the ninth day of the disease, after the injection of $\frac{1}{3}$ grain atropine the pulse-rate rose from 100 to 108—that is, "escaped" 8 beats.

				"Escape."	
				8 beats.	
On the 13th day	...	...	82-90	...	12
" 17th day	...	...	58-70	...	12
" 21st day	...	...	78-92	...	14
" 27th day	...	...	80-110	...	30
" 36th day	...	...	84-120	...	36

CHART V.—Case of paratyphoid A. Fully inoculated, eight months previously, against typhoid only. Bacillus recovered from blood, and positive to agglutinations. A = Atropine $\frac{1}{3}$ gr.

Case of Paratyphoid B in an Inoculated Man.

The patient was a man aged 21, who had been inoculated five months previously against typhoid and para-

typhoid A and B. The case was proved bacteriologically, the bacillus being recovered from the stools. (See Chart IV.) On the twelfth day, after the injection of atropine $\frac{1}{32}$ gr., the pulse-rate rose from 94 to 98.

On the 16th day	...	90-98	...	"Escape."
" 19th day	...	78-88	...	8 beats
" 24th day	...	78-100	...	10 "
" 29th day	...	76-90	...	22 "
" 33rd day	...	70-82	...	14 "
" 38th day	...	70-98	...	12 "
				28 "

Case of Paratyphoid A in an Inoculated Man.

The patient, a man aged 30, had been inoculated eight months previously against typhoid only. (Chart V.) On the day of the first injection of atropine (the sixteenth day of the disease) the pulse failed to regain its initial rate, and so lost five beats a minute. This extreme reaction is apparently more common in the paratyphoids than in the true typhoid. On the twenty-sixth day, after the injection of atropine $\frac{1}{32}$ gr., the pulse-rate rose from 102 to 106.

On the 35th day	...	78-88	...	"Escape."
" 40th day	...	86-104	...	10 beats
" 46th day	...	88-120	...	18 "
" 53rd day	...	80-118	...	32 "
				38 "

It will be noted in each of the diseases shown that during some period of the illness the pulse-rate fails to quicken under the influence of atropine in the normal manner.

CHART VII. Case showing fleeting reaction in a very mild case of paratyphoid B infection. A = Atropine $\frac{1}{32}$ gr.

week of the disease, and one or more observations during this period have shown its presence in the vast majority of cases. I have seen it well marked on the fifth day, often on the seventh day, most constantly about the tenth day. It has disappeared by the fourteenth

CHART IX.—Inoculation experiment on a man who had never been inoculated, and whose blood did not agglutinate either typhoid or paratyphoid A or B. On the twenty-first day after an inoculation of $\frac{1}{2}$ c.cm. of T.A.B. vaccine, and the ninth after an inoculation of 1 c.cm. of the same vaccine, the blood agglutinated all three organisms. A = Atropine $\frac{1}{32}$ gr. V = T.A.B. vaccine $\frac{1}{2}$ c.cm. V' = T.A.B. vaccine 1 c.cm.

day, but has persisted as late as the hundredth day, waxing and waning with relapses, although apparently not confined to the febrile period.

Safeguards against Erroneous Deductions.

Age.—It must be remembered that, with advancing years, the heart normally responds less and less to the

action of atropine, so that in individuals over 50 a diagnosis of a typhoid group should be made with reserve if the acceleration is more than 10 beats a minute. My experience has been confined to males between 17 and 47 years of age.

Previous Cardiac Disease.—From my early experience of the action of atropine on sclerotic conditions of the heart, I learnt that victims of cardio-sclerosis failed to respond by quickening in the usual manner. Fallacies from this cause must be excluded in applying the test.

Rapid and Irregular Action of the Heart.—Observations upon such cases are liable to lead one astray for obvious reasons. (See Chart VIII.) Atropine itself may cause extra-systoles (very occasionally), and in these cases the observations are untrustworthy.

The Effect of Inoculation upon the Atropine Curve.

After some difficulty in finding such an individual I was able to record the effect of equal doses of atropine upon an uninoculated man and then on certain days to repeat the experiment after an inoculation with typhoid vaccine. Chart IX shows the reaction as observed throughout. Two observations previous to first inoculation showed an escape of about twenty-two beats, then on the fifth day after $\frac{1}{2}$ c.cm. typhoid and paratyphoid A and B vaccine, the reaction began, the rate being raised from 60 to 70

CHART VIII. In this chart is seen the reaction to atropine obtained on several days of a "suspect" bacteriologically negative to typhoid group and subsequently regarded as a case of bronchopneumonia. I do not regard this as an example of a positive atropine reaction, as the extreme height of acceleration under the atropine is approximately the same on each occasion. A = Atropine $\frac{1}{32}$ gr.

beats only; on the seventh day the rate fell from 76 to 72 beats; on the ninth day the rate was again raised from

CHART X.—Effect of a single dose of vaccine on the atropine curve in a young man. (Note how soon after inoculation the effect is evident.) Previous to inoculation the blood did not agglutinate either typhoid or paratyphoid A or B. After inoculation the blood agglutinated all three organisms. A = Atropine $\frac{1}{32}$ gr. V = T.A.B. vaccine $\frac{1}{2}$ c.cm.

74 to 80 beats. The second dose of T.A.B. vaccine was administered on the eleventh day.

By the eighteenth day the pulse fell from 86 to 78. On the twenty-first day the pulse fell from 84 to 80. On the thirty-third day the pulse rose from 80 to 88. On the fortieth day the pulse rose from 84 to 96. On the fiftieth day the pulse rose from 74 to 90.

Agglutination tests previous to inoculation showed the individual to be free from infection of the typhoid group, recent or old, and also that he had not been inoculated, whereas after inoculation he was shown to possess agglutinins against typhoid and paratyphoid infections.

A notable feature of the cases which proved to be of meningeal origin was the excessive acceleration after atropine—from 40 to 60 beats—a point which may assist in the diagnosis of suspects of that class of diseases.

Total Analysis.

The observations on the following 200 cases of "suspects" were carried out according to a uniform routine by the sisters in charge, and were made within a day or two of admission to hospital, and no case beyond the twenty-first day of his disease is included.

In addition to this series I have records of about 100 cases which were examined by myself before the single routine was established. These are not included, because I wished to control my own series.

Analysis of 200 Cases, with Bacteriological Diagnoses.

36 cases: Typhoid, paratyphoid A and B bacillus isolated and positive to agglutination. The reaction was shown in 34, poorly marked in one, and entirely absent in the other—a fatal case, in which the pulse-rate was never relatively slow, of death being discovered at autopsy.

58 cases: Mixed. Positive to agglutination only. The reaction was shown in 45, absent in 13.

101 cases: Declared to be negative to typhoid or paratyphoid A or B infections. The reaction was present in 8.*

5 cases: Declared to be "carriers" bacteriologically proven. The reaction was always absent.†

I have experimented with various doses on normal individuals, and found that with $\frac{1}{32}$ grain or more the acceleration of the pulse was practically constant.

A very noticeable feature of the test is that individuals suffering from a typhoid group infection show a remarkable tolerance to atropine, and the other effects—for example, thirst, pupillary changes, etc.—are apparently in abeyance. A glance at Chart XIII would seem to show that the test may be applied indefinitely.

Further investigation may reveal the fact that other diseases may produce this phenomenon, but so far this reaction has been a very constant clinical sign in typhoid and paratyphoid fevers and has so frequently been supported at a later date by the bacteriologist.

Before closing I wish to express my thanks to Professor Dreyer, Lieutenant-Colonel Gratton, Captain Wood, R.A.M.C., Captain Perry, R.A.M.C., Captain Young, R.A.M.C., Captain Bazett, R.A.M.C., Captain Tytler, C.A.M.C., and Captain Shanks, C.A.M.C., for the bacteriological controls, and to Sisters Annandale and Best, who toiled ungrudgingly at such a tedious task.

NOTE.—An account in detail with further observations on 400 cases is about to be presented for publication.

* Some of these cases showed such a remarkable resemblance clinically to these diseases that the possibility of an undiscovered member of the group occurs.

† From these and other cases I conclude that the reaction is indicative of active disease only.

It is reported that the French Government has reason to expect that stretcher-bearers may shortly be returned from Germany, where they have hitherto wrongfully been detained prisoners.

CHART XI.—Case of bronchitis. Bacteriologically free from typhoid and paratyphoid A and B infections. A = Atropine $\frac{1}{32}$ gr.

Chart X shows the great rapidity with which the reaction to the atropine test may develop after a single dose of vaccine given to a young man. From a total of six observations similar to the above it appeared that inoculation would affect the atropine reaction for probably ten weeks, and I conclude that the atropine reaction should be repeated after a few days if a "suspect" has been inoculated within that time. In these cases a definite conclusion can be drawn only when the change under atropine is well marked in one direction or the other after a second observation. Further observations are needed to determine precisely the limits of such a reaction.

The Action of Atropine on other Febrile Conditions.

The opportunity of making prolonged observation on many other febrile conditions was unfortunately not available to me, so that it is only upon such suspects as appear below that I have had any experience, because the cases which were shown bacteriologically to belong to other diseases than the typhoid group were soon removed from the hospital in which I was working.

Charts XI, XII, and XIII, are from cases clinically diagnosed as bronchitis, trench fever, and pyrexia of unknown origin, and bacteriologically free from typhoid or paratyphoid A or B infections. In each case it will be noticed that at every observation the heart is seen to respond to the atropine in the normal manner.

Among the "suspects" the following diseases were diagnosed and failed to show the reaction:

Bacteriologically proven:

- Dysentery, bacillary and amoebic.
- Cerebro-spinal fever.
- Pulmonary tuberculosis.
- Tuberculous meningitis.
- Miliary tuberculosis.
- Septic meningitis.
- Malaria.
- Relapsing fever.
- Typhoid and paratyphoid fever carriers.
- Jaundice, excepting when associated with typhoid and paratyphoid infection.
- Gaertner.
- Septicaemia.

Clinically:

- Trench fever.
- Bronchopneumonia.
- Pneumonia.
- Pleurisy.
- Rheumatism.
- Influenza.
- Rheumatoid arthritis.
- Appendicitis.
- Pyrexias of obscure origin.
- Meningismus of unknown origin.

CHART XII.—Case of trench fever. Bacteriologically free from typhoid and paratyphoid infections. A = Atropine $\frac{1}{32}$ gr.

CHART XIII. A typhoid "suspect" examined daily and proved to be bacteriologically negative to typhoid group. A = Atropine $\frac{1}{32}$ gr.