RESEARCHES

ON

THE MECHANICAL DILATATION OF THE CERVIX UTERI, AND THE APPLIANCES USED FOR THE PURPOSE.

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THE investigations, the results of which are given in the following paper, were begun simply with a view to greater exactness of knowledge of the powers and uses of the various means employed to dilate the cervix uteri in obstetrics and gynaecology. As the inquiry advanced, numerous physiological and therapeutical points arose in my mind, which appeared to throw light on it, or to be themselves illustrated; and to some of them reference will be made.

For the dilatation of the cervix uteri, cutting instruments are occasionally used, but no account of their action is here attempted, as it is of the simplest kind, and its power is practically unlimited. The means to which attention will be directed are:

1. The bougie.
2. The tangle-tent.
3. The sponge-tent.
4. The India-rubber bag, commonly made fiddle-shaped, and named after Barnes.

All of these may be used, and are used, in obstetrics and gynaecology; the last, or India-rubber bag, is used almost exclusively in the former. Besides these, there are several other methods of dilatation in use, such as that by the instruments of Rigby and of Priestley; but I have not included these in the present inquiry.

The numerous experiments to be referred to were all made in the laboratory of Professor Tait, and I am indebted and grateful to this gentleman not only for assistance and suggestions of every kind, but especially for the necessary calculations made in order to reach the results of the various experiments.

There are many elements in the action of the above-mentioned four means of dilating the cervix uteri which are worthy of investigation and discussion; but three are evidently chief, and will alone be now described. They are:

- I. The amount of force exercised.
- II. The amount of expansion produced.
- III. The amount of time required for producing the expansion.

I.—THE AMOUNT OF FORCE EXERCISED.

1. *The Bougie.*—The cervix uteri, and especially its internal os, may be dilated by a succession of bougies. The rounded and somewhat conical point of the bougie having in every longitudinal section that passes through the point nearly a wedge-shape (Fig. 2), must act under pressure as a wedge does; but the shape of the point is so ill-defined and so various that it is impossible to make definite statements regarding the actual force exerted by it under any given circumstances, and only very general statements will be attempted. The flat rounded point of the ordinary uterine probe has a wedge-shape (Fig. 1) of so large an angle

Fig. 1.—End of an Uterine Probe, magnified. Fig. 2.—End of an Urethral Bougie. Fig. 3.—Imaginary end of a Bougie.

as to destroy almost entirely any wedge-like action which it otherwise might possess. This flattened point is necessary, because the point must be both short and blunt. Were it sharp, it would be apt to catch on the rugosities of the arbor vite, and it might prick or otherwise injure the mucous membrane. In the larger bougies used for dilatation, there is space for an arrangement or conformation that cannot be made in the slender, small ordinary uterine probe. The extreme point or angle of the wedge is rounded off or destroyed, and a blunt point ob-

tained, as in the ordinary uterine probe; but there is still a considerable and an efficient part of the now blunted or pointless wedge left between the rounding off or blunting and the shoulder, or part where the whole point joins the stem of the bougie. This wedge-shaped point it is that effects the dilatation desired, if the constricted part is to be gradually expanded or burst asunder by main force.

Before proceeding farther, it is desirable to estimate the amount of force or pressure that may be applied to the base of this bougie wedge. Now it is evident that this force is, theoretically speaking, limited only by the strength of the instrument; but this strength will give no estimate of the amount safely or ordinarily applied in actual practice. To ascertain what is the amount used in practice, I have used two plans. I have observed that in using great force to pass a common uterine probe, the instrument is bent; and by experiment I find that the force required to bend the instrument, applied as in gynaecological practice, is about four pounds exerted at its point, the handle being fixed. Again, taking a bougie in the hand, and pressing it appropriately against a balance or steel-yard with as much force as I permit myself to use in practice, I find that the pressure exerted at the point is about four pounds. In calculating, therefore, the dilating force of the wedge-like ends of common male urethra bougies, as used for uterine dilatation, I shall suppose a forward pressure of four pounds to be exerted on the base of the wedge.

Now, with this same force used, the tension overcome will be the greater in proportion as the wedge is sharper or has a smaller angle, supposing that the same breadth of surface of the wedge is pressed upon. It is plain, then, that the smaller bougies, having generally sharper points, or wedge-points of smaller angle, will have more force to dilate than the larger bougies with wedge points of larger angle, the extreme point being in both cases excluded. Two bougies may be supposed and compared, and it may be assumed that the surface pressed upon in the cervix is one-tenth of an inch in breadth, then the dilating force exerted will be about 9 lbs. if the wedge have an angle of 90 deg., or 90 lbs. on the square inch, and about 18 lbs. if the wedge have an angle of 45 deg., or 180 lbs. on the square inch. Probably both of these angles are exemplified in the male urethral bougies, which are used in gynaecological practice. Should exactness in the amount of force used be desired, it may be approximately attained by the construction of bougies which have an ascertained wedge-angle in the active part of the point.

The larger bougies have their rounded ends so made (Fig. 2) that the thickest part of the wedge-like point, or that nearest the shoulder, forms a wedge of smaller angle than the parts nearer the extreme point. In consequence it happens that the further the point is introduced the instrument is, *ceteris paribus*, more powerful. To make this clearer, I have introduced Fig. 3. Were a bougie so constructed, its wedge-like point would be weaker and weaker, *ceteris paribus*, in proportion as it was further and further introduced, because the wedge near the shoulder is of much larger angle than near the point.

When, in discussing dilatation of the internal os of the cervix, I speak of the extent of surface of the wedge-like point of the bougie that is actually pressed upon as being one-tenth of an inch, I make an assumption, but it is certainly not very wide of the truth; for that the internal os is a short strait, is proved by the sudden or jerk-like manner in which it is permeated by a dilating bougie: there is no considerable length of passage to dilate. Besides, in cases where a tangle-tent passed through this strait fails to expand it, the tent, when forcibly withdrawn, exhibits a mould of the strait. There is an indentation where the counterpressure of the internal os acted. The longitudinal extent of the deepest portion of this indentation is not far from one-tenth of an inch.

2. *The Tangle-Tent.*—This does not act as a wedge. It is used in the form of a cylindrical piece of dried vegetable cellular tissue. When it is in use, it is passed through the part to be dilated, and, absorbing water by an osmotic or a capillary force, it enlarges with great power, and distends the constricted part. The expanding force of the tangle-tent was ascertained in two different ways. First, an apparatus was used to test how great a weight the expanding tent could raise. This apparatus consisted of two metallic beams articulated together at one end, and having flat well-fitting surfaces. Where the surfaces came into contact, canals were cut out to accommodate tents of various sizes. Half of each canal was in the upper metallic beam, half in the lower (Fig. 5). A tent was passed into a canal, which it filled pretty exactly; the apparatus was then plunged into water and the weight adjusted upon it (see Appendix). As the tangle expanded, it elevated the weight. Second, an India-rubber strap was rolled around a tent at an ascertained tension, and its ends fixed by ligature to the tent. The tent so treated was then plunged into water, and it was observed whether it became expanded or not. These varied experiments showed that the expanding force of the tent rose as high as 500 lbs. on the square inch, or even higher; in one experiment, as high as 640 lbs. on the square inch.

In the cases of the tangle-tent, sponge-tent, and India-rubber bag, the extent of the part to be dilated is immaterial, because the same, or nearly the same, force is exerted at every point of the tent or bag, whether a small or a large portion, or the whole surface of the tent or bag, be opposed to the constriction or resistance.

3. *The Sponge-Tent.*—The sponge-tent acts in the same manner as the tangle-tent, but its power is very much less. It was not tested in the metallic apparatus or clamp, but with the India-rubber band wrapped around it at an ascertained tension. By this means it was found to exert a force in expanding equal to from 20 lbs. to 30 lbs. on the square inch.

4. *The India-rubber Bag.*—In order to test this, good specimens were obtained in the ordinary shops. It was easy, by the use of a manometer, to find exactly what pressure they exerted or withstood when distended by the ordinary barrel or otherwise shaped India-rubber syringe, supplied along with them. They were found at the highest to exert a pressure equal to from 15 lbs. to 25 lbs. on the square inch. The pressure was found to be greatest when they were fully and equably distended; afterwards, becoming deformed and thinned in parts, previously to ultimately bursting, the pressure became considerably lessened.

II.—THE AMOUNT OF EXPANSION PRODUCED.

1. *The Bougie.*—By the use of this instrument, an amount of expansion is produced which is susceptible of exact measurement. The size of an aperture or passage being ascertained by transmitting easily through it as large a bougie as will pass, a larger bougie is then urged through it with some expenditure of force, and the difference between the diameters of the round stems of the two bougies is a measure of the amount of dilatation effected. In ordinary practice, the amount of dilatation effected at one sitting is not considerable: it amounts to from .02 to .04 inch in the diameter of the part dilated; but, by prolonging the sitting and using a succession of instruments, or using one large instrument very long and perseveringly, a greater amount of dilatation may be effected: .02 or 1-50th of an inch is the average difference between the diameters of two successive bougies in the ordinary male urethral series, and these may be used in gynecology, or, by trivial changes, adapted for gynecological purposes. The series, as procured in such a well known surgical cutler's shop as Mr. Young's, runs thus: 7 = .16, 8 = .18, 9 = .20, 10 = .22, 11 = .23, 12 = .24, 13 = .26, 14 = .28, 15 = .30, 16 = .32, 17 = .34, 18 = .36, 19 = .38 inch. I cannot conceive why this regularity of the series is broken at 11, nor have I been able to find out. If there be any reason, it is surgical, for the series tested is the ordinary surgical series. The whole series, if successfully used, produces a dilatation of about a quarter of an inch.

2. *The Tangle-Tent.*—The expansion of a tent of this kind when it is subjected to no pressure is considerable. A tent whose stem has about one-fifth of an inch in diameter expands to about half an inch in diameter, and other sizes expand in a like proportion; but this amount of expansion is not a good measurement of what this tent can do by mere mechanical force, for, in proportion as the resistance to be overcome by the expansion increases, so does the amount of actual expansion decrease. A tangle-tent raising by expansion a weight of 300 lbs., enlarges to a degree which in medical practice would be regarded as almost nothing. In one of the experiments made, it was found that a tangle-tent of .36 inch in diameter, expanding with a force of nearly 166 lbs. per square inch, increased its diameter only from .36 to .43, or about 1-14th of an inch. The same tent, under a pressure of nearly 500 lbs. on the square inch, enlarged only from .406 to .43, or 1-40th of an inch. To fully appreciate the insignificance of this enlargement, it is necessary to remember the length of time—at least many hours—consumed in producing this amount of dilatation. The minute dilatation effected at a sitting by a bougie one degree larger than its predecessor used at a former sitting, is produced almost instantaneously.

3. *The Sponge-Tent.*—The amount of expansion of a sponge-tent, when not under any constraint, is greater than that of the tangle-tent. A small sponge-tent of one-third of an inch in diameter will expand to a little more than an inch, more than trebling its diameter; but it is very compressible; and a reference to the experiments, in the Appendix, shows that the expansion, even under slight compression, is very small indeed.

4. *The India-rubber Bag.*—The expansion produced by the India-rubber bag is practically unlimited on the side of great extent. Small bags are not available, or have at least not yet been introduced into practice. But, beginning with the smallest bag in ordinary use, about the thickness of a finger, further expansion is practically unlimited, because any bag can be easily withdrawn and another of larger size immediately substituted for it. This is not true of the other methods of dilatation, if the important and danger-bringing element of time be kept in view in considering the matter practically. This mode of expand-

ing is greatly different from that of the sponge or tangle-tent, for it maintains its full power until the complete regular expansion of the bag is arrived at. It does not, like them, expand to a slight degree with moderate or great force, and then become weak; for, by keeping up the repletion of the bag, it may be made to maintain the same force from the first moment of application to the last degree of regular expansion.

III.—THE AMOUNT OF TIME EXPENDED IN PRODUCING THE EXPANSION.

This element in the production of expansion is one of the most important for the consideration of the practitioner. He may wish speed for its own sake, or he may find it essential with a view to avoid the risk of the supervention of inflammation.

1. *The Bougie.*—No time is lost in bringing the full power of this appliance into action.

2. *The Tangle-Tent.*—Even when under no constraint whatever, this dilating agent expands slowly. Before its small dimensions have doubled, twelve hours will have elapsed. When there is considerable mechanical resistance to the expansion, it is, compared with this, to a very slight degree in amount, and very slowly produced. Particulars under this head will be found in the Appendix of Experiments.

3. *The Sponge-Tent.*—Almost no time is lost in bringing out the full power of this agent. Sometimes time is lost in the melting of the lard and wax with which such tents are smeared; but when the fluids get access to the sponge, it is scarcely so much as a matter of minutes to produce full expansion when the sponge is unconstrained; but under pressure its power of expansion is small, and the amount also very small.

4. *The India-rubber Bag.*—No time is lost in bringing into action full power of this method, and its power continues till the full expansion of the bag.

[To be continued.]

CASE OF WOUND OF INTESTINE: RECOVERY.

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T. R., aged 24, labourer, stout built, tall, and well-proportioned, received a wound in the abdomen on the right side, two inches and a half from the umbilicus, and on a parallel line with it. He was stabbed with a knife, its blade being three inches long, and extremely sharp to the very point. From the appearance of the wound, which was three inches long and gaping, I should say that the instrument had passed downwards, and then had been torn upwards and outwards. I found the man in a semi-conscious state, nearly an hour after he had received the injury. The loss of blood had been great. The omentum was protruding; also a portion of the ileum, the latter being punctured. The wound in the gut was longitudinal, and half an inch long, and from the aperture was exuding a thin dark-coloured fluid. I at once, after examining the wound carefully, applied a stitch (glover's) with the thread saturated in a weak solution of carbolic acid. I returned it with the omentum to the cavity of the abdomen, closed up the external wound of the parietes by ligature, also saturated with solution of carbolic acid, and over all placed a pad of carbolised lint, with a bandage extending from the pelvis to the extremity of the sternum. I gave every three hours an ounce of a mixture composed of a grain of tartrated antimony in eight ounces of water, and a grain of opium in pill every four hours.

Twelve hours afterwards peritonitis set in, when I increased the dose of opium to two grains three times a day, and continued the mixture of antimony.

On the fourth day I examined the wound, and found it looking remarkably healthy, and healing by the first intention, and the peritoneal symptoms somewhat abating. I lessened the dose of opium to one grain every four hours. His diet up to this time had been barley-water, with a little milk; no solid food whatever.

On the seventh day the bowels acted, and he passed a dark viscid stool, and again complained of considerable pain.

I continued the opium till the tenth day, on the evening of which day the bowels again acted, this time without any pain whatever; I therefore only gave him half a grain of opium at bed-time, combined with two grains of calomel. Next morning the bowels again acted, and he expressed himself free from pain.

The patient at this time was very much reduced, from the treatment adopted. I then ordered beef-tea, and the milk diet was continued.

On the fourteenth day he was able to leave his bed; from that time gradually but slowly recovered, and I considered him convalescent on the twenty-eighth day.