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A STUDY OF INTRA-ABDOMINAL PRESSURE WITH PRACTICAL DEDUCTIONS.*

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Mr. President and Gentlemen:—I wish this evening briefly to call your attention to some of the physiological phenomena connected with intra-abdominal pressure, developing from them for your consideration a few conclusions of practical importance to those laboring in the gynecological field.

The questions which I propose to answer in this study are: (1) When we stand erect are the abdominal viscera under pressure, and if so, do the abdominal muscles exercise constant tonic pressure upon their contained viscera? or, (2) Do the viscera so fill the abdomen as to make pressure from within outward? or, (3) Are these forces so balanced as to give no intra-abdominal pressure at all?

The important points in this investigation I worked out thirteen years ago, while yet a resident physician in the Episcopal hospital

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of Philadelphia, in connection with a paper, never published, upon "The Mechanism of Defecation."

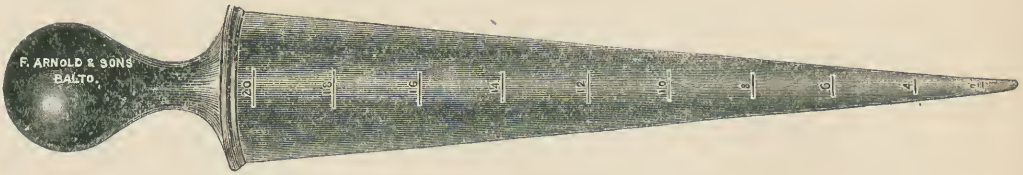

FIG. 1.—Urethral calibrator; short lines indicate diameter in millimetres.

FIGS. 2 and 3.—Double urethral dilators. The smaller sizes, Nos. 5 and 6, are only used when calibre of ureter is very small or narrowed by stricture.

While in Germany, in 1884, I found the first reference to this subject in an article by Prof. Schatz upon the "Druckverhaltnisse im Unterleibe," and during my visit I had the pleasure of talking with Prof. Schatz upon this subject.

The accumulated clinical observations of the past twelve years, which, carefully observed, are often more valuable than experiments, have in many points changed my views, however, and I bring them before you to-day as an original contribution.

For the purposes of our study, the abdomen may be considered a cylinder, both of whose ends are closed by a diaphragm —the pelvic floor below and the muscular diaphragm above.

The size and form of the abdominal cavity are subject to the greatest variations, depending upon the respiratory movements, cardiac and arterial pulsations, the condition of the alimentary tract, whether full or empty, and the posture of the patient. To allow for such change, the abdominal walls are endowed with great elasticity. This elasticity has a limit, however, beyond which the tension becomes abnormal.

The difference in capacity existing in

the abdominal cavity between the normal repletion, as when the intestines, bladder and stomach are full and when they are empty, may be called the "ordinary reserve space," while the difference in capacity between the empty cavity and the one greatly distended by advanced pregnancy, great obesity, tumors or ascitic fluid may be designated the "extraordinary reserve or supplemental space." In 1865, Braune studied this subject experimentally by injecting water into the rectum and then inserting a manometer, when he found that there was a rise in the external tube as high as the diaphragm. From this he concluded that the water injected had risen within the abdomen to the transverse colon, and that his experiment simply demonstrated the law of hydrostatic paradox, and that there was no intra-abdominal pressure.

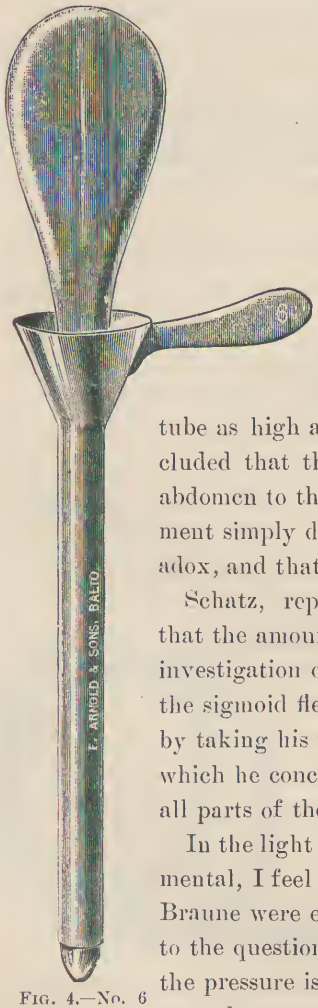

FIG. 4.—No. 6 speculum (natural size). This size is used when urethra is very small or in inspecting the bladder in children.

Schatz, repeating Braune's experiment, observed that the amount of water injected by the latter in his investigation often was not sufficient to rise beyond the sigmoid flexure. He avoided this source of error by taking his pressure curves from the bladder, from which he concluded that there is a definite pressure in all parts of the abdomen.

In the light of my studies, both practical and experimental, I feel that the deductions of both Schatz and Braune were erroneous. I believe the correct answer to the question is the following: In the erect position the pressure is positive in the lower part of the abdomen, decreases towards the middle of the abdomen and becomes negative above. That this is true, I have been able to demonstrate by simultaneously inserting a manometer into the bladder, distended with water, and a tube into the stomach; under these conditions I have shown an actual suction in the stomach tube, while there was a rise of 60

cm. in the manometer in the bladder, thus proving the assertion that the pressure above is negative, while below it is positive.

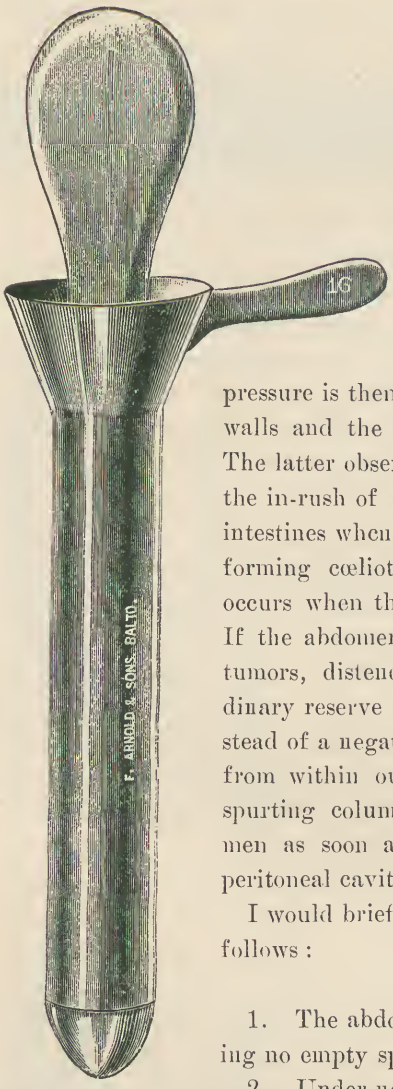

FIG. 5.—No. 16 speculum (natural size). This speculum is usually the maximum size used in cystoscopy or catheterization of ureters.

This pressure below is simply the result of the gravitation of the viscera down onto the lower abdomen and the pelvic floor. When the patient takes the recumbent posture the viscera gravitate into the flanks and the manometer registers little or no pressure in the pelvis; the negative pressure is then beneath the anterior abdominal walls and the positive pressure in the flanks. The latter observation is confirmed clinically by the in-rush of air and the dropping away of the intestines when the abdomen is opened in performing cœliotomy. This phenomenon only occurs when the reserve space is not occupied. If the abdomen is filled with ascitic fluid, large tumors, distended intestines, etc., the extraordinary reserve space is fully taken up, and instead of a negative there is a positive pressure from within outwards. This is shown by the spurting column of ascitic fluid from the abdomen as soon as the incision is made into the peritoneal cavity.

I would briefly summarize my conclusions as follows:

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1. The abdominal cavity is a plenus, containing no empty space or vacuity.

2. Under normal conditions the limits of the capacity of the abdomen are not encroached upon; that is to say, there remains an available reserve of several litres, varying with the elasticity or the laxity of the abdominal walls in the individual under examination.

3. The statement that there is no pressure within the abdominal cavity made by Braune is erroneous.

4. The statement that the abdominal walls exercise a definite tonic pressure upon the contained viscera, and that the pressure is equal, or approximately equal, throughout, is also erroneous.

FIG. 6.—Speculum and obturator (two-thirds natural size).

5. Under conditions which do not involve the active use of the abdominal muscles, the intra-abdominal pressure is simply due to the effect of gravity upon the movable viscera, acting like a column of fluid.

6. Under these circumstances, in the erect position the pressure is positive in the pelvis and lower abdomen at the same time it is negative in the stomach.

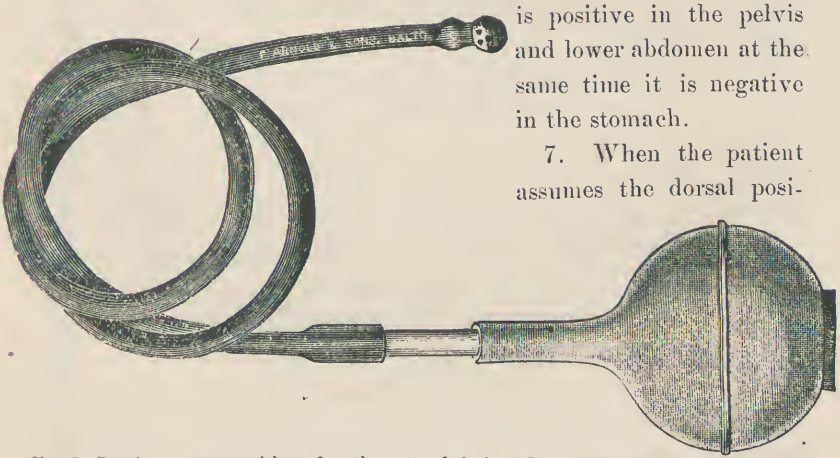

FIG. 7—Suction apparatus (three-fourths natural size) used for withdrawing residual urine.

7. When the patient assumes the dorsal position, the pressure is often negative over the anterior abdominal wall and positive beneath the flanks.

8. In the half-reclining position the pressure will be between the minimal and maximal (6 and 7) in a condition of rest.

9. Any active use of the abdominal muscles greatly increases the intra-abdominal pressure, which becomes positive throughout.

10. By elevating the pelvis above the thorax, the reverse conditions to those detailed in No. 6 are obtained, the pressure in the upper abdomen becoming positive, while it becomes negative in the lower abdomen and pelvis.

11. In consequence of the pressure being negative or sub-atmospheric, if an opening offers at any place the air rushes in, attempting to fill the space and equalize the pressure.

12. The possibility of the gravitation of the viscera causing positive pressure in the most dependent part and negative pressure in the part most elevated, depends upon the existence of the available reserve spoken of.

13. If the available reserve is exhausted by the encroachment of bowels distended by gas or by large tumors or ascitic accumulations, the suction phenomena do not appear.

14. The greatest available reserve is secured with stomach, intestines and bladder empty. Under these circumstances, upon elevating the pelvis and producing negative pressure, if the vaginal outlet is opened air rushes in and balloons out the vagina.

15. If the urethra is distended, air rushes in, filling the bladder.

16. If the anus is dilated, air rushes in, filling the rectum and part or all of the sigmoid.

* * * *

The utilization of these facts in the examination of the uterus and appendages, the bladder, rectum and vagina, is of the greatest practical aid. If you will place the patient previous to examination in the knee-breast posture, or while she is in the dorsal posture elevate her hips well above the thorax, the movable

FIG. 8. — Delicate mouse-toothed forceps (three-fourths natural size).

abdominal viscera will gravitate towards the diaphragm and thus render the uterus and its appendages accessible to the most delicate examination when the patient is returned to the dorsal position, as the viscera do not return at once to their former position in the pelvis. In this way the most delicate adhesions of tube and ovary and other obscure lesions can readily be mapped out.

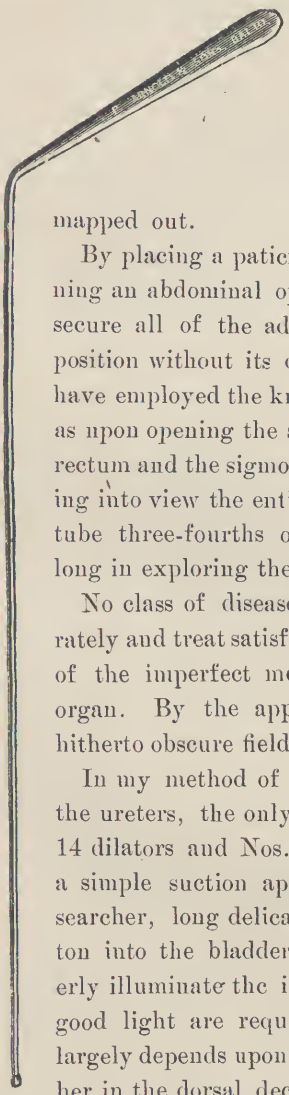

FIG. 9.

By placing a patient in one of these postures before beginning an abdominal operation, you will frequently be able to secure all of the advantages afforded by the Trendelenburg position without its disadvantages. For the last ten years I have employed the knee-breast posture in rectal examinations, as upon opening the sphincter ani air rushes in and distends the rectum and the sigmoid flexure, ballooning them out and bringing into view the entire mucous membrane. I employ a metal tube three-fourths of an inch in diameter and twelve inches long in exploring the sigmoid flexure.

No class of diseases has been so difficult to diagnose accurately and treat satisfactorily as those of the bladder, on account of the imperfect methods of examining the interior of this organ. By the application of this principle, however, this hitherto obscure field has been opened to direct inspection.

In my method of exploring the bladder and catheterizing the ureters, the only instruments necessary are the Nos. 8 to 14 dilators and Nos. 10 to 13 specula with their obturators, a simple suction apparatus, a ureteral catheter, a ureteral searcher, long delicate forceps for carrying pledgets of cotton into the bladder, and small pledgets of cotton. To properly illuminate the interior of the bladder, a head mirror and good light are required. The success of this examination largely depends upon the posture of the patient. Upon placing her in the dorsal decubitus, with hips elevated upon cushions from 18 to 30 cm. above the table, and passing a speculum through the urethra, the bladder distends with air and is accessible

FIG. 9.—Ureteral Searcher.

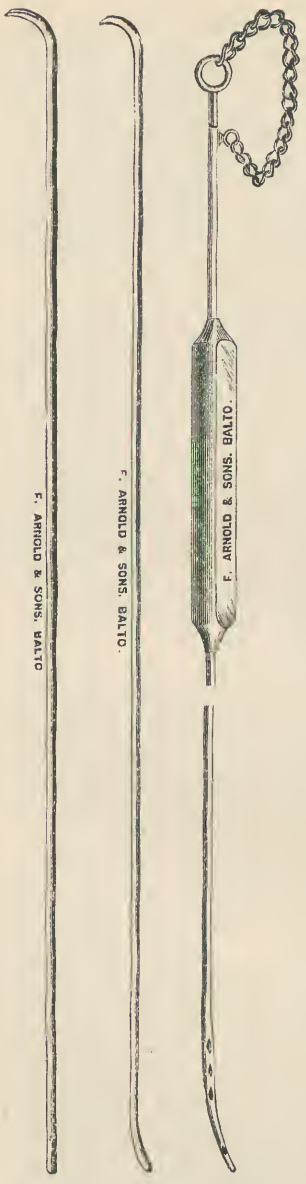

FIG. 10. FIG. 11. FIG. 12.

FIGS. 10 and 11.—Ureteral catheters without handles for direct catheterization through speculum.

FIG. 12.—Ureteral catheter with handle sufficiently reduced to allow speculum to be withdrawn after catheter is engaged in ureteral orifice

to inspection. The following simple procedure suffices: First dilate the urethra, using the graduated dilators up to 11 or 12 cm., the bladder is emptied and a speculum corresponding in size to the last dilator is inserted and the obturator withdrawn. The urine is removed with the suction apparatus and the pledgets of cotton. By inclining the speculum to one side or the other about thirty degrees from the median line of the body, the ureteral orifices are usually easily found. Not only is it possible to catheterize the ureters with ease, but the entire bladder wall can be inspected. In this way one can readily discover isolated areas of hyperæmia, inflammation, ulceration, tuberculosis, and, in fact, all microscopic lesions.

This method of inspecting the bladder and catheterizing the ureters has opened up a great field for the gynecologist. I have within the past six months had a number of opportunities of demonstrating its value. But a short time since I was able to catheterize the ureters in a case of pyonephrosis, in which pus could be seen flowing from the ureter of the affected side while normal urine escaped in jets from the opposite side. The patient was pale and much emaciated and had been under the care of a number of very capable specialists.

In another case of pyuria, I discovered a sinus leading from the posterior wall of the bladder into a tuberculous pyosalpinx.

And so many times weekly I am called upon to examine the bladder and catheterize the ureters in this way, thus clearing up doubtful conditions, applying direct topical treatment, in numerous instances diagnosing stricture of the ureter, and localizing purulent foci in one kidney or the other and paving the way for a successful operation.