J. Physiol. (1955) 129, 448–453

THE EFFECT OF POSTURE ON BLADDER PRESSURE

By D. W. GOULD, A. C. L. HSIEH AND L. F. TINCKLER
From the Departments of Physiology and Surgery, University of Hong Kong

(*Received* 11 *November* 1954)

During the course of an investigation into the behaviour of the ureter (Gould, Hsieh & Tinckler, 1955*a*, *b*), it became apparent that this organ is adapted to the task of feeding urine into the bladder against a considerable resistance, and also of protecting the kidney against high pressures developed at its lower end.

The necessity for these functions remained obscure, since we shared the common view that bladder pressure remains low, except during micturition, by virtue of the power of adaptation shown by the muscle of the bladder wall in the face of filling (Denny-Brown & Robertson, 1933). These authors found that resting vesical tension at moderate volumes varied from 5 to 10 cm of water, and came to regard this range as the normal pressure of the vesical contents. Lapides (1948) states that in the normal individual intra-abdominal and intravesical pressure are approximately constant.

It then occurred to us that investigations into bladder pressures have always been carried out on animals or human subjects who were lying down. It seemed probable that a change of posture such as would cause the bladder to bear the weight of the intestines would necessarily produce a rise in intravesical pressure.

As a simple preliminary experiment to test this view, a long glass tube was attached to a catheter which had been passed into the bladder of an elderly man for another purpose. Taking the symphysis pubis as an arbitrary reference point, it was found that urine rose in the tube to a height of 6 cm when the patient was lying down, and to a height of 36 cm when he stood up.

We therefore undertook an investigation into the effect of posture on bladder pressure.

METHODS

We acted as our own subjects and enjoyed, in addition, the help of two volunteers. A stretcher was fixed to a length of piping so that it could be swung vertically through 360°. The subject swallowed a small latex rubber balloon attached to a length of rubber tubing. He was then secured to the stretcher (as it lay horizontal) by a harness, and by having his feet bound to a foot-board. A catheter was passed into the bladder. A stethograph was fixed around the chest.

Pressures from bladder, stethograph and the balloon in the stomach were recorded by Statham strain-gauge manometers fixed to the side of the stretcher and connected to a Sanborn 'Poly-Viso' physiological recorder. The manometer recording bladder pressure was placed so that it lay to the side of the subject along the horizontal axis of the bladder. Thus manometer and bladder were both at the same level, whatever the tilt of the stretcher.

Intravesical and intragastric pressures and respiratory movements were then recorded with the subject in positions varying from upright to upside down.

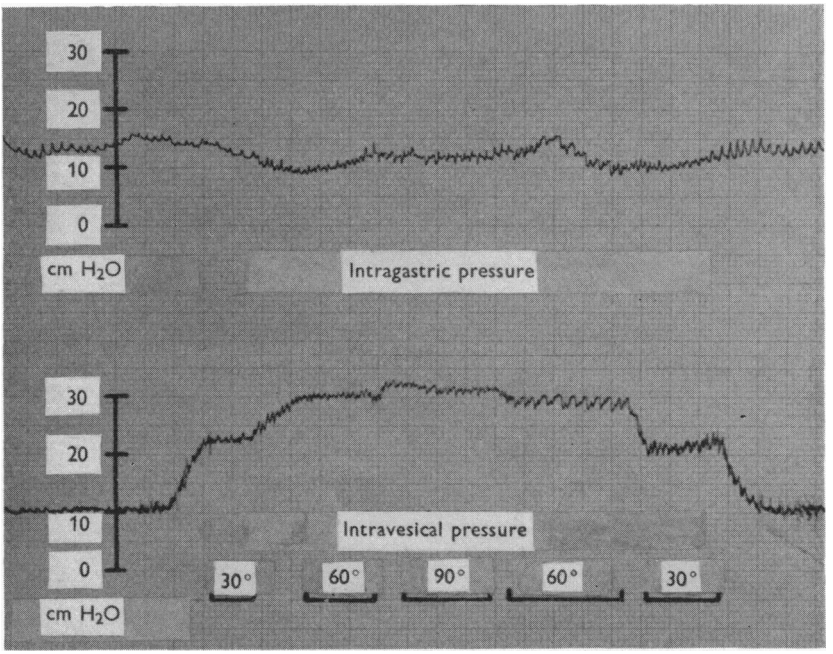

Fig. 1. The effect upon intravesical and intragastric pressures of tipping the subject from the horizontal to the upright position and back again. Pauses were made at tilts of 30, 60, and 90°. Speed of trace: one small square in 2 sec.

RESULTS

Bladder pressures in the supine position varied from person to person and ranged between 6 to 15 cm water. Upon tilting from the horizontal to the vertical position, pressure in the bladder rose progressively; much the greater part of the total rise having occurred by the time a tilt of 60° was achieved. The increase varied with each subject, ranging between 14 and 25 cm of water. Final pressures varied from 22 to 40 cm of water. There was a coincident slight fall in intragastric pressure (Fig. 1 and Table 1).

Tilting to the head-down position caused a rise in intragastric pressure and a sharp drop in the pressure recorded from the bladder. In the four subjects

who were tilted in this direction to the full 90° recorded bladder pressure fell below zero (Fig. 2).

Bladder pressure was recorded in one subject while he sat upright with legs hanging over the edge of the stretcher. This position resulted in a rise of pressure similar to that produced when the same subject was tilted into the upright position (from 6 up to 22 cm of water).

TABLE 1. Bladder pressure from five subjects recorded in the horizontal and upright positions

	Bladder pressure in cm of water		
Subject	Horizontal	Upright	Increase
1	6	22	16
2	9	23	14
3	10	32	22
4	12	36	24
5	15	40	25

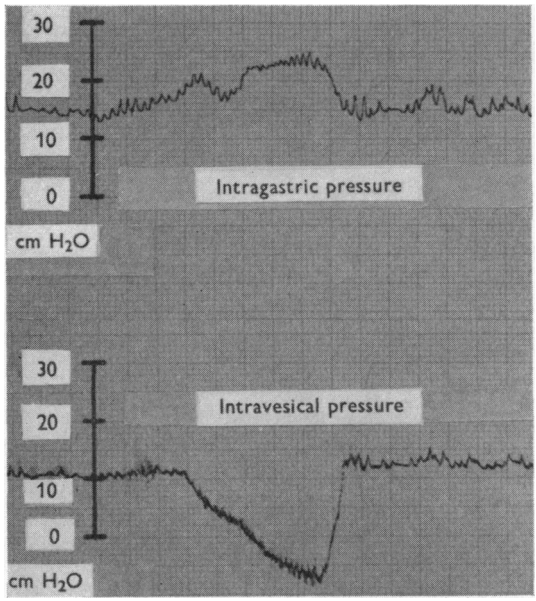

Fig. 2. The effect upon intravesical and intragastric pressures of tipping the subject through 90° from the horizontal to the head down position and back again. Speed of trace: one small square in 2 sec.

An incidental finding concerned the effect of respiration on intra-abdominal pressure. In two of our subjects deep breathing in the upright position caused an appreciable fall in intra-abdominal pressure; the fall being coincident with inspiration (Fig. 3). This effect had been noticed also at the time of the original

experiment on the elderly hospital patient. In the remaining three subjects, and in all subjects when lying down, inspiration caused the expected rise in intra-abdominal pressure.

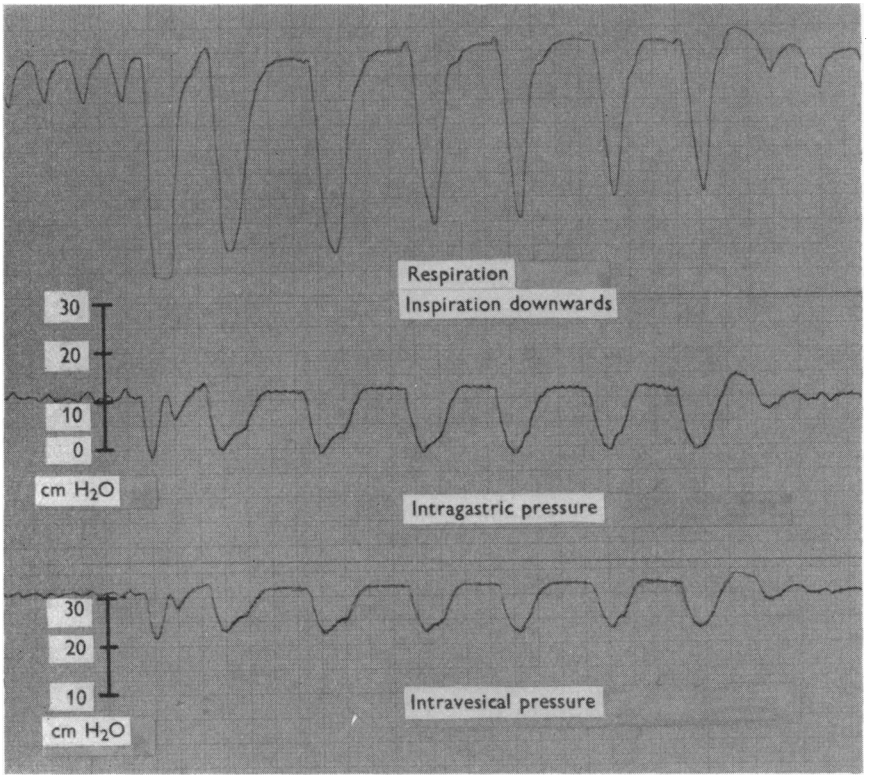

Fig. 3. The effect of normal deep breathing upon the intragastric and intravesical pressures of one of the subjects when upright. Speed of trace: one large square in 2 sec.

DISCUSSION

The fact that intragastric pressure does not rise, but falls slightly, as the body becomes upright shows that the increased pressure recorded from the bladder is a true rise of intravesical pressure, and not merely a rise of intra-abdominal pressure. The most likely explanation for this increase in bladder pressure is that in the upright position the bladder has to bear the weight of the intestines. This idea is supported by the fact that an increase in intragastric pressure occurs when the body is tilted head down. Part of the sharp fall away of bladder pressure recorded in the head down position is probably an artifact, and due to the urine in the bladder weighing the fundus down below the level of the recording manometer.

One of our subjects was a woman 28 weeks pregnant. Her bladder pressure when lying down was 15 cm of water as against 40 cm when upright. These pressures are only slightly higher than those achieved by the nearest male subject (12 and 36 cm of water respectively). It does not seem, therefore, that the pregnant uterus adds very dramatically to the weight borne by the bladder, although further measurements in pregnant women are obviously needed.

From these observations it follows that for the better part of the 24 hr, the ureters are faced with the task of feeding urine into the bladder against an appreciable resistance; and the role of the ureters in securing an efficient drainage of urine from the kidneys is perhaps a more active one than is commonly envisaged.

An upright animal like man will rest his intestines upon the bladder more consistently than the four-footed beasts; but quite a small tilt is sufficient to raise bladder pressure appreciably, and it seems reasonable to suppose that a squatting dog, or a sheep grazing on a slope, tail to the valley, will experience a sustained rise of bladder pressure sufficient to make it necessary that their ureters also should be organized to work against resistance.

Since standing up causes this large rise in bladder pressure, and yet does not ordinarily produce a desire to micturate, it must be assumed that distension rather than a high intravesical pressure is the adequate stimulus to bladder contraction. The two must be distinguished.

The finding that in certain subjects deep breathing in the upright position produces a sharp fall in intra-abdominal pressure is an interesting one. We are experimenting further in the matter. Meantime, it would seem necessary to qualify the statement that inspiration raises the intra-abdominal pressure.

SUMMARY

1. Intravesical and intragastric pressures, together with respirations, have been recorded in five human subjects in various postures.

2. Moving from the horizontal to the upright position produces a two- to threefold rise or more in bladder pressure.

3. This rise in bladder pressure is probably due to the weight of the abdominal contents bearing upon the organ.

4. The fact is noted that in certain persons in the upright position, deep inspiration causes a sharp fall in intra-abdominal pressure.

It is a pleasure to acknowledge our debt to a colleague and to the wife of one of us who so cheerfully acted as additional subjects.

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