SOME CIRCULATORY RESPONSES TO VALSALVA’S MANOEUVRE IN PATIENTS WITH POLYNEURITIS AND SPINAL CORD DISEASE

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The response of the arterial blood pressure and of the capacity vessels, or veins, of the hand to Val-
salva’s manoeuvre was investigated in two patients
with complete traumatic lesions of the spinal cord
in the cervical region and in two patients with severe
acute polynuclear.

METHODS

Arterial blood pressure was recorded through a Courand
needle inserted into the brachial artery. Distensibility
of the capacity vessels was measured by comparing
the increase in hand volume resulting from intermittent
obstruction of the venous return from the hand with the
simultaneous rise in venous pressure of the hand.

Hand volume changes were measured with a water-
filled plethysmograph of 5-16 litres capacity. The water
was stirred continuously and its temperature maintained
at 34 ± 0-5°C. The patient lay supine with the hand in the
plethysmograph at the level of the manubriosternal joint.
The water within the plethysmograph exerted a hydro-
static pressure of 8 to 11 cm. water upon the dorsum of
the hand. Hand volume changes were derived from
pressure changes of the air contained within the turret of
the plethysmograph. Ambient temperature was constant
throughout each investigation, within the range 22 to
25°C.

Venous pressure was measured through a nylon
catheter of 0-8 mm. internal diameter introduced per-
cutaneously on the dorsal or radial aspect of the radiocarpal joint and directed peripherally. The catheter was
made to negotiate at least one venous valve and the end
of the catheter lay about 5 cm. distal to the site at which
the vein was punctured. Care was taken that the end of
the catheter was not wedged in a venous tributary.
The catheter was periodically flushed with 0-2 ml. of a
solution of saline containing 0-01 mg./ml. of heparin.

All pressures were measured with capacitance trans-
ducers (Southern Instruments), and records were obtained
with a four-channel direct-writing pen unit. The pens
were 16 cm. long, worked in an arc of 4 cm., and had a
peak to peak response time of 0-07 second. The paper
speed usually used was 5 mm./second.

An occluding pneumatic cuff was placed round the
wrist immediately proximal to the plethysmograph and
intermittently inflated to 40 mm. Hg for 10 to 20 seconds.
During each period of venous occlusion the hand volume
and venous pressure were continuously recorded.

EXPRESSION OF RESULTS

The increase in hand volume was expressed graphically against the increase in hand venous pressure. The measured increase in hand venous pressure included the transmitted rise in pressure within the plethysmograph as a consequence of increase in hand volume. The true rise in venous pressure was therefore derived by subtracting the rise in pressure within the plethysmograph from the total rise in venous pressure. As the rise of pressure within the plethysmograph during an episode of occlusion of venous return never exceeded 7% of the total rise in venous pressure, this correction was small.

The transmural hand venous pressure, or venous distending pressure, was derived by subtracting the hydro-
static pressure, due to the column of water within the plethysmograph above the back of the hand, from the venous pressure. This hydrostatic pressure always exceeded the resting hand venous pressure. As the hydrostatic pressure was directly transmitted to both hand tissues and hand veins the venous distending pressure was near zero between episodes of venous occlusion, indicating that the veins were collapsed (Ryder, Molle, and Ferris, 1944).

PROCEDURE

After the apparatus had been set up, no measurement of capacity vessel distensibility was made for about 30 minutes. Twenty consecutive records were then analysed. The tracheal pressure of the patient was then increased to 40 mm. Hg for 20 seconds. During this time, and for the following five minutes, arterial blood pressure was continuously recorded and frequent measurements were made of the distensibility of the capacity vessels.

Finally, all of the patients were given noradrenalin by intravenous infusion at 2 µg./minute for six minutes to determine whether the capacity vessels could alter their distensibility in response to direct stimulation.

SUBJECTS

Each of the four patients had severe respira-
tory weakness or paralysis, and received intermittent
positive pressure respiration from a Radcliffe respiration
pump (Russell, Schuster, Smith, and Spalding, 1956)
through a cuffed tracheotomy tube (Spalding and Smith,
1956) which provided an airtight seal in the trachea. All
patients had clinically and radiologically normal lungs
at the time of investigation.

Because of respiratory weakness, and because the
patients had tracheotomies, they were unable to perform
Valsalva's manoeuvre by straining against a closed glottis. A source of pressure was therefore applied to the trachea and maintained at the desired level for 20 seconds. As these patients were unable to raise their intra-abdominal pressure by straining when the intrathoracic pressure was raised, it is probable that the stress cast upon the circulation was greater than normal, as blood could probably also be dammed back within the abdomen.

The response of the arterial blood pressure to Valsalva’s manoeuvre was also investigated in three normal healthy subjects.

RESULTS

Fig. 1 is a record of the response of the arterial blood pressure to Valsalva’s manoeuvre in a normal subject. Initially the arterial blood pressure was transiently raised as the elevated intrathoracic pressure was transmitted directly to the mediastinal arteries. A progressive fall of diastolic arterial blood pressure and of pulse pressure followed, and continued for about five to 10 seconds. The diastolic blood pressure then began to rise and the pulse pressure increased. When the intrathoracic pressure fell at the end of the manoeuvre a sharp transient fall in blood pressure occurred, as the reduction of intrathoracic pressure was transmitted to the mediastinal arteries. Finally, the diastolic pressure and pulse pressure increased markedly, both exceeding their previous resting values. During this characteristic 'overshoot' of the arterial blood pressure bradycardia occurred. The arterial blood pressure returned to normal within 30 seconds of the end of the Valsalva manoeuvre.

Fig. 2a is a record of the arterial blood pressure obtained during Valsalva’s manoeuvre in a patient with severe acute polyneuritis. While the intrathoracic pressure remained high, diastolic blood pressure and pulse pressure fell progressively. When the manoeuvre was concluded the diastolic pressure and pulse pressure returned slowly to their initial values. No ‘overshoot’ of the arterial blood pressure was seen and no bradycardia occurred. Fig. 2b is a record similarly obtained from a patient with a complete traumatic lesion of the cervical spinal cord.

FIG. 1

FIG. 2a

FIG. 2b

FIG. 1. Record of the arterial blood pressure response to Valsalva’s manoeuvre performed by a normal subject. Upper trace intrathoracic pressure, lower trace, arterial blood pressure, time in seconds.

FIG. 2a. Response of arterial blood pressure to Valsalva’s manoeuvre in a patient with acute severe polyneuritis. Upper trace, intrathoracic pressure, lower trace, arterial blood pressure.

FIG. 2b. Response of arterial blood pressure to Valsalva’s manoeuvre in a patient with a complete traumatic lesion of the cervical spinal cord.
with a complete lesion of the spinal cord at the second cervical segment.

Figs. 3a and 3b show the distensibility of the capacity vessels of the hand of the two patients with severe polyneuritis. The solid dots represent values obtained before the Valsalva manoeuvre, and each point shown represents a mean derived from 20 episodes of occlusion of the venous return. The crosses represent values obtained during the Valsalva manoeuvre, and the raised hand venous pressure found during the Valsalva manoeuvre is due in part to the damming back of blood within the systemic veins as a result of raised intrathoracic pressure and in part to local occlusion of venous return with the pneumatic cuff. The values shown are mean values derived from two or three performances of the Valsalva manoeuvre. The triangles represent values obtained after the Valsalva manoeuvre was completed: each point shown is a mean value derived from 20 consecutive episodes of venous occlusion starting immediately after the end of the Valsalva manoeuvre. No change in the vascular distensibility of the hand was found as a result of raising the intrathoracic pressure. Similar results obtained on two patients with complete lesions of the cervical part of the spinal cord are shown in Figs. 4a and 4b.

Figs. 5a to 5d demonstrate the reduction in distensibility of the capacity vessels of the hand which occurred when these patients were given an intravenous infusion of noradrenalin at 2 \( \mu g/\text{minute} \). The triangles represent values obtained after
Valsalva’s manoeuvre immediately before noradrenaline, and the solid dots those obtained during noradrenaline infusion.

DISCUSSION

The technique used in this investigation for measuring the distensibility of the capacity vessels is similar to that employed by Sharpey-Schafer (1961) for determining the vascular pressure-volume relationship of the forearm. It is related to the plethysmograph methods of measuring venous distensibility in vivo (Clark, 1933; Kidd and Lyons, 1958; Glover, Greenfield, Kidd, and Whelan, 1958; Eckstein and Horsley, 1960). The vessels investigated are the low pressure capacity vessels, which consist almost entirely of veins (Litter and Wood, 1954). These vessels were collapsed by the imposed hydrostatic pressure of the fluid within the plethysmograph, so that a reasonably constant baseline hand venous volume was assured (Clark, 1933).

The abrupt raising of the mean intrathoracic pressure which occurs during Valsalva’s manoeuvre (Valsalva, 1707) causes a marked fall in the filling pressure of the right side of the heart (Lee, Matthews, and Sharpey-Schafer, 1954). Blood pressure changes and alteration of blood flow in the forearm in response to this have been extensively investigated in normal subjects (Sharpey-Schafer, 1953, 1955) and in patients with chronic disease of the afferent nervous system (Sharpey-Schafer, 1956). The capacity vessels of the hand in normal subjects become constricted during Valsalva’s manoeuvre (Watson, in preparation), and this constriction is probably
Some circulatory responses to Valsalva's manoeuvre in patients with polyneuritis and spinal cord disease

SUMMARY

Arterial blood pressure and the distensibility of the capacity vessels of the hand were measured in two patients with severe polyneuritis and in two patients with complete lesions of the cervical part of the spinal cord. These patients showed an abnormal response of the arterial blood pressure to the Valsalva manoeuvre, and failed to show the normal reduction in hand venous distensibility in response to the Valsalva manoeuvre.

I am greatly indebted to Dr. W. Ritchie Russell, Dr. J. M. K. Spalding, and Dr. A. Crampton Smith for the opportunity to study patients under their care and for research facilities. Dr. E. Seelye helped in the presentation of the paper and the records were photographed by Mr. Tugwell of the Radcliffe Infirmary. The investigation was supported by a grant from the National Fund for Research into Poliomyelitis and Other Crippling Diseases.

REFERENCES