Queckenstedt's test
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SUMMARY

Isovolumetric CSF pressure recording provides a very accurate analogue of hydrodynamic events occurring in the subarachnoid space. This study was undertaken to determine normal parameters of CSF pressure rise and fall on jugular compression for electro-manometric CSF pressure measurement and to assess the usefulness and clinical validity of this method.

I. Queckenstedt's test - the use of bilateral jugular compression in the detection of a spinal canal obstruction - has been a useful adjunct to neurological diagnosis for more than 50 years. The simple open-end water manometer has hitherto served as the device for visualizing CSF pressure variations and it remains in clinical use, despite many attempts at technical refinement. More sophisticated manometry, especially the isovolumetric method, has contributed substantially to the understanding of the hydrodynamics of the CSF spaces.

The Monro-Kellie doctrine, viz. that the sum of the volumes of blood, CSF and brain substance within the skull is constant, is still a fundamental basis of CSF hydrodynamics. The problems of CSF secretion and absorption, dural distensibility and elasticity, and the relationship between CSF pressure and venous pressure have been greatly elucidated by the investigations of Weed, Flexner, Masserman and Bering. However, the particular hydrodynamic events occurring on jugular compression have received but scant attention: only Verjaal, Taylor and to a lesser extent Gilland advanced theories explaining the mechanism of Queckenstedt's test. One of the most valuable advances in the detection of spinal subarachnoid obstruction has been the introduction of functional manometry by Kaplan and Kennedy. By its means intermittent subarachnoid obstruction in the cervical area can be detected, and lesions of the bony cervical canal inflicting damage on the spinal cord better understood.
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Lidvall and particularly Gilland were the first to report on the use
of electromanometric equipment for spinal block detection.
II. Since 1965 electromanometric CSF pressure recording has been
carried out by the author in the Department of Neuroradiology of
the University Hospital of Groningen. A puncture needle, after
introduction into the dural sac, is connected to a pressure transducer
by means of flexible tubing and the system filled with distilled
water; no CSF leaves the subarachnoid space. The CSF pressure
variations are transmitted via the fluid-filled tubing to a diaphragm
in the pressure transducer. Minimal diaphragmatic movements cause
small changes in the distance between two plates forming a capaci-
citor; these changes in capacitance are detected by electronic cir-
cuity and recorded by means of an ink-writing recorder. Testing
of the electromanometric equipment revealed that its fidelity within
a range of 0-7 cm was undistorted - a requirement generally accepted
as adequate.

A total of 104 consecutive CSF pressure recordings, divided into
2 series, was analysed with respect to the CSF pressure changes on
jugular compression in the various head positions. In a limited num-
ber the CSF pressure changes occurring on abdominal compression,
on Valsalva's manoeuvre, and following withdrawal of 10 cm² CSF
were studied on the tests mentioned. The CSF pressure rise and
fall were determined. Basic pressure, maximal pressure, closing pres-
ure and pulse amplitude were measured. The shape of the pressure
curves was evaluated according to a preestablished classification.
The results were matched with the findings of neuroradiological
examinations and surgical procedures. Most information was ana-
lysed by a digital computer.

III. The classical open-end manometer shows rise and fall of the
CSF level on Queckenstedt's test within a matter of seconds. The
isovolumetric method monitors these pressure variations more faith-
fully: under normal circumstances a rise or fall occurs in less than
0.5 second. Cineradiological recording of the behaviour of myelo-
graphic contrast medium on jugular compression in the cervical
region confirmed this, in that very abrupt movements of the con-
trast column were demonstrated. Apparently CSF is displaced,
which is possible only if the dural sac is distensible. The properties
of the dural sac are of utmost significance in this connection. Nor-
nally it is under a certain stretch and tension. Evidence of the
elasticity and distensibility of the dura was found, i.e. in the moderate-
largely damped cardiac pulsations present in the CSF, the amplitude
of which diminishes on lowering of the CSF pressure. It became
apparent that the logarithm of the CSF pressure was linear on
withdrawal of CSF in equal volumes, as was the logarithm of CSF
pressure on jugular compression; both these lines were found to
run parallel. However, this linearity disappeared after withdrawal
of a certain volume of fluid, indicating that the factor of dural
elasticity had ceased to operate and the dura was completely relaxed.
From this point it was reasoned that events in the epidural space
determined the course of further diminutions in pressure.

The normal CSF pressure curve on jugular compression shows an
abrupt change in the rise, the steep phase being followed by a more
gradual one. This sudden transition can be explained by the role
of the collateral venous circulation. Jugular compression causes an
increase in the intracranial blood volume. CSF is displaced caudally
and increases the volume of the dural sac. The latter becomes more
distended with a consequent increase in both the CSF pressure and
the venous pressure (the CSF pressure and the intradural venous
pressure are identical). An appreciable increase in the venous pres-
sure forces a collateral circulation to open up and the CSF pressure
can reestablish. The significance of the epidural space lies in the
presence of an extensive venous plexus which can easily compensate
for changes in the volume of the dural sac.

IV. By means of quantitative analysis it could be demonstrated
that the angles for the rise and fall of CSF pressure on jugular com-
pression were fairly constant in normal subjects, and that the angle
for CSF pressure fall was larger than for CSF pressure rise. The angle
for CSF pressure fall appeared to be a more reliable indication of
the presence of spinal subarachnoid obstruction than the angle for
rise - a finding not recorded in the literature. Most obstructions
were found upon performing Queckenstedt's test with the head in
retroflexion. These findings indicate the importance of performing
Queckenstedt's test with the head in retroflexion, and of paying
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appraisal of the CSF pressure recordings. The well-known observa-
tion that high CSF pressures are accompanied by cardiac pulsations
of greater amplitude was confirmed by quantitative analysis. Fur-
thermore, the relationship between the height of the CSF pressure
and the pulse amplitude proved to be a linear one.
V. The clinical validity of the electromanometric method was
found to be good, and apparently contradictory results in certain
cases could be explained. However, its clinical usefulness is
limited: electromanometry proved to be of diagnostic aid only in
patients with cervical lesions, particularly in the differential diag-
nosis of intermittent obstruction (spondylotic myelopathy, pincer
mechanism, narrow spinal canal). Also, it determined the choice of
contrast medium to be used: subarachnoid obstruction - particu-
larly the intermittent variety - is thought most amenable to study
by positive-contrast myelography, because this medium permits
functional myelographic examination of the subarachnoid space.

It seemed likely that in patients with a myelopathy due to cer-
vical spondylosis (often in conjunction with a narrow spinal canal)
treated by extensive laminectomy, the operative results were better
if electromanometric examination had demonstrated a spinal sub-
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The authors classification of the various shapes proved helpful in the diagnosis of obstruction, and visual evaluation of CSF pressure curves - i.e. interpreting the CSF pressure tracings without mathematical analysis - sufficed for accurate diagnosis; more detailed study was shown to be superfluous. Following the withdrawal of 10 cm$^3$ of CSF, the results of jugular compression became unreliable: more abnormal shapes were encountered and the angles for CSF pressure rise and fall approximated the sharper angles seen in cases of spinal subarachnoid obstruction.

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VI. Several other phenomena became apparent during this study of the CSF pressure curves. Respiratory fluctuations may vary, but the presence of Antoni's respiration sign of obstruction is of diagnostic significance. Changes in the cardiac rhythm should be recognized. The presence of contrast medium in the dural sac may lead to erroneous interpretations.

VII. Attention was paid to the effect of Valsalva's manoeuvre, i.e. straining, on the CSF pressure. In an appreciable number of instances a secondary pressure wave was observed following cessation of straining; its form proved to be fairly constant. The phenomenon of the secondary pressure wave could be related to the variations in cardiac minute volume. The occurrence of this secondary pressure wave was not confined to Valsalva's manoeuvre, it was also observed in certain individuals following jugular compression as a consequence of triggering a carotid sinus reflex.