Functional Inactivation of the Human Brain Stem
Related to the Level of Consciousness

Intravertebral Injection of Barbiturate*

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It is a common opinion among neurosurgeons and neurologists that damage to
the rostral brain stem is associated with,
and probably responsible for, coma. The reticular formation is considered to be the
brain stem structure whose integrity is essential for a normal level of consciousness.
There are many publications dealing with
this subject and supporting this view.46 On
the other hand, some recent observations in
our laboratory on the effect of barbiturate
injection into the vertebral circulation of
man,2,6,4 seem to lead to different
conclusions. No distinct change in the level
of consciousness was recorded following the
direct introduction of amobarbital sodium
(Amytal) into one vertebral artery.

The brain stem up to the caudal thalamus
usually receives its blood supply from the
vertebral arteries.26 A drug injected directly
into these vessels, therefore, is likely to affect
the neurons of the brain stem structures selec-
tively. In the case of intravertebral injec-
tion of a barbiturate depression of brain stem
activity should occur. This has actually been
demonstrated in experiments on cats81 and
rabbits.21,49 The sensitivity of the reticular
formation to barbiturates is well known.6,13,
18,19,25 Therefore, if the maintenance of a
normal level of consciousness is dependent
upon reticular function, the intravertebral
administration of a barbiturate should al-
ways result in loss of consciousness.

The apparent discrepancy between
generally accepted views on the neural mecha-
nism of consciousness and our findings led us
to re-investigate our previous finding2,5 of
absence of any effect from intravertebral
amobarbital on the level of consciousness.
We then tried to find out whether brain stem
structures such as the nuclei of cranial nerves
having a well-known function were affected;
in particular, we wanted to make sure that
the brain stem neurons are really depressed
by intravertebral amobarbital. Thirdly, we
tried to discover whether the barbiturate is
distributed to all levels of the brain stem,
including the rostral midbrain; this was done
by examining the somatomotor, visceromo-
tor and somato sensory functions of certain
cranial nerves. Fourthly, the possibility of
difference in sensitivity to barbiturates in
the various brain stem structures or func-
tions was considered. Finally, an analysis
was made of the effects of barbiturates on
electroencephalographic activity.

The results reported below were found in
patients who had to undergo intravertebral
amobarbital injection for diagnostic pur-
poses. Direct introduction of this barbiturate
into the cerebral circulation is usually limited
to the carotid system; this technique is used
by us and by others for the identification of
cerebral dominance,1,3,9,16,39-41,44,50-60 for the
identification of the focus in epileptic
patients,17,38,51,52 and for the study of diskinetic
and diatonic disease.4,6,22,36 The first injec-
tions of amobarbital into the vertebral sys-
tem of man were made accidentally while
attempting an intracarotid injection.2 Intra-
vertebral amobarbital was found not to be
dangerous in these first fortuitous cases. We
therefore decided to apply this method to
the study of epilepsy and certain extra-
pyramidal diseases. All the studies were per-
formed with the full knowledge of the patient
who had previously been informed of their
nature. In all patients the intravertebral amo-
obarbital injection was immediately preceded
by vertebral angiography. We have reported

Received for publication November 30, 1964.
* Supported in part by the Consiglio Nazionale delle
Ricerche (Impresa di Elettrofisiologia), and by the Air
Force Office of Scientific Research OAR, through the
European Office of Aerospace Research, US Air Force
(Grant AF-EOAR 65-4 and Contract AF 61-032-901).
here only those cases showing a normal angiographic picture.

Method

Nineteen patients with a normal angiographic picture of the vertebro-basilar arterial system were examined. The vertebral artery, usually on the right side, was reached percutaneously in the neck according to the technique of Lindgren. The amount of amobarbital used ranged between 3 and 100 mg. The drug was diluted to 1–5 per cent with saline or distilled water and injected over about 3 seconds. The electroencephalogram (EEG), electrocardiogram, frequency of respiration and electrical activity of some muscular groups were continuously recorded on an ink-writing electroencephalograph. The blood pressure was measured with a Riva Rocci instrument. The motor component of the 3rd, 4th, 5th, 6th, 7th and 12th cranial nerves was examined by direct observation of their function. Particular attention was devoted to the pupillary size. The sensory function of the 5th nerve was examined through tactile and pain stimulation. Simple motor and sensory examination of at least one arm or leg was usually performed. As already described, evaluation of the level of consciousness was based on the following criteria: general behavior of the patient; his ability to react correctly to the order to perform a given movement, an order which was given before or immediately after the injection of the barbiturate, and his capacity to recollect afterwards what was said or done during the examination. The intravertebral injection of amobarbital was always preceded by the injection of an equal amount of saline: the latter never produced any neurological or EEG effect.

Results

Motor functions. The first motor phenomenon which followed the intravertebral injection of a very low dose of amobarbital (10–20 mg.) was nystagmus; 2 or 3 seconds after the beginning of the injection, there was horizontal nystagmus; the direction of the rapid and slow components was not constantly related to the side of the injection. The nystagmus disappeared within 40–60 seconds, but in some instances it could be observed even after 4–5 minutes during lateral gaze.

Dose of 30–60 mg. of the drug always produced the following immediate paretic phenomena in the muscles innervated by the cranial nerves: bilateral ptosis of the superior eyelids, variable deviation of the eyes, opening of the mouth because of loss of tone in the jaw muscles (the jaw did not deviate to right or left), bilateral smoothing of the nasolabial furrow, puffing out of both cheeks with respiration, and inability to protrude the tongue. These paretic phenomena lasted about 3–4 minutes.

Postural fixation and movements of the limbs were preserved; after the injection the subject was still capable of maintaining his arms horizontally extended in front of him, or to perform voluntary movements. There were, however, errors in rate, range and direction of movements of the arms that revealed a disturbance of coordination.

Sensory functions. The most obvious and constant sensory disturbance was vertigo. Even with low doses (10–20 mg.) of amobarbital the patient complained that the external world appeared to move, usually in a rotary fashion. With larger doses of the drug the phenomenon was much more marked and disturbing.

Sensitivity to light touch and pin prick in the cutaneous sensory field of the 5th nerve was sometimes reduced by 30–60 mg. of barbiturate. The hyphesthesia appeared almost immediately after the intravertebral injection and gradually disappeared in about 2 minutes. Unlike the motor deficit, the sensory defects were not observed in all patients.

We never observed loss of hearing nor impairment in the appreciation of vibratory, tactile and painful stimuli applied to the four limbs. However, the examination of the auditory function was not carried out with a technique sufficiently refined to reveal the possible existence of slight deafness.

Visceral functions. A marked dilatation of both pupils was always produced by the doses of amobarbital causing oculomotor and facial paralysis (30–60 mg.). The mydriasis immediately following the injection of the drug disappeared gradually in 3–4 minutes. The blood pressure was not depressed even by 100 mg. of amobarbital. Only slight and short lasting irregularity in the respiratory rhythm was observed. The heart frequency was usually increased during the 20–30 seconds which followed the injection.

Reflexes. The pupillary light reflex and the corneal reflex were suppressed bilaterally by 30–60 mg. of amobarbital. They disappeared simultaneously with the appearance of ocu-