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Neurosurgery – Contemplation of the Future

J. Lawrence Pool M.D.

Abstract
When I was a medical student 42 years ago my neurological textbooks were replete with diagrams of the motor, sensory, visual, and speech areas of the cerebral cortex. It occurred to me then that perhaps the viscera might also have cortical representation and therefore why not try to find out if this were so? Sad to say I was dissuaded from investigative attempts on the grounds that time in medical school should be spent only on learning. (In this respect, I would urge that any of you with promising investigative ideas should put them to the test and not be persuaded to forget them. For sad experience has shown that if you don't do the job, someone else will!). Since my early days, much has been learned about the visceral representation in the cortex of the brain, to part of which I eventually contributed. It is now known, for example, that the vagus nerve nucleus has a representation in the subfrontal cortex, bladder and bowels in the juxtamotor cortex, cardiac and respiratory control in the cingulate and medial temporal cortex, and sex organs also in the latter. Pupillary changes may be elicited by stimulating the anterior cingulate gyri, intussception by stimulating posterior cingulate gyri, while blood pressure alterations may be induced on stimulation of numerous parts of the cerebral cortex. All this adds up to the now well-known fact that in addition to a motor and sensory cortex, there is also what might be termed a " visceral brain" in man and beast(9).

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NEUROSURGERY - CONTEMPLATION OF THE FUTURE

J. Lawrence Pool, M.D.

When I was a medical student 42 years ago my neurological textbooks were replete with diagrams of the motor, sensory, visual, and speech areas of the cerebral cortex. It occurred to me then that perhaps the viscera might also have cortical representation and therefore why not try to find out if this were so? Sad to say I was dissuaded from investigative attempts on the grounds that time in medical school should be spent only on learning. (In this respect, I would urge that any of you with promising investigative ideas should put them to the test and not be persuaded to forget them. For sad experience has shown that if you don't do the job, someone else will!) Since my early days, much has been learned about the visceral representation in the cortex of the brain, to part of which I eventually contributed. It is now known, for example, that the vagus nerve nucleus has a representation in the subfrontal cortex, bladder and bowels in the juxtamotor cortex, cardiac and respiratory control in the cingulate and medial temporal cortex, and sex organs also in the latter. Pupillary changes may be elicited by stimulating the anterior cingulate gyri, intussception by stimulating posterior cingulate gyri, while blood pressure alterations may be induced on stimulation of numerous parts of the cerebral cortex. All this adds up to the now well-known fact that in addition to a motor and sensory cortex, there is also what might be termed a "visceral brain" in man and beast[9].

More recent and on-going studies in our laboratories[3] suggest there may also be what might be called a "metabolic brain". For example, stimulation of certain discrete areas within the hypothalamus and more remote but related parts of the brain by means of microelectrodes, in cats and other animals, induces an almost immediate and massive mobilization of fat, after a meal, into the circulating blood, and at the same time causes the blood to clot within a matter of seconds instead of several minutes. Here then is a possible mechanism by which coronary or cerebral vascular accidents may be produced. A stressful situation following a heavy meal may, via hypothalamic mediation, cause a dramatic increase in fat in the circulation. This mobilization of fats increases blood viscosity and the blood tends to clot rapidly. The combination of these two factors within a narrowed sclerotic coronary or cerebral artery could obviously lead to its occlusion. This preliminary work, although not yet definitive, suggests how the brain may play a role in causing a serious systemic disease, such as a stroke or coronary attack.

Other work in our medical center has indicated the presence of a new hormone-like protein, derived from the hypothalamo- pituitary system, which appears essential for synchronous peristalsis of the gut. Preliminary studies suggest that this hormone is deficient in persons afflicted with gastro-intestinal disorders such as ulcerative colitis, and that the latter can be relieved in some cases by administration of this hormone[6]. This perhaps is another example of metabolic control of body organs by the brain.

More familiar examples are fluid, electrolyte and sugar regulation by hypothalamic and brain stem nuclei, and endocrine control by the hypothalamic-medial temporal-pituitary axis. Recent work[12] indicates that even the pulmonary circulation may be drastically altered by the autonomic nervous system activity.

What has all this to do with the future? Increasing evidence points to the influence of the brain in regulating systemic activity. I would suggest that perhaps *all* body functions, metabolic, hematologic, endocrine, visceral, autonomic and even pulmonary circulation[12] may be controlled or regulated by the brain.

Further efforts should be made, I feel, to understand how the brain and its chemistry affects the various moods and emotions whose aberrations can lead to mental illness, including schizophrenia[10]. A good deal, of course, is known about the anatomy of these circuits such as that of the limbic system and its specific thalamic and hypothalamic links. The future, I would suggest, offers the possibility of a brand new and far more promising kind of brain-mapping, based on the well established fact that various cell types of the central nervous system, be they neurons or glial cells, have individual biochemical characteristics with respect to their nucleic acids, organelles, enzyme systems and synaptic transmitters. A dramatic example of this possibility is afforded by the fluorescent histochemical technique developed by Falck and Owman for detecting monoamine-containing nerve terminals[4]. This tool has already afforded us new insights into the function of the nigral-straital system that was impossible by conventional histological methods. The excitement generated by each new discovery in the metabolic pathways of L-DOPA, and the therapeutic success of this amine, may well be duplicated when more is understood about the function of other amines, particularly norepinephrine.

Sophisticated application of radioactive tagging techniques offer a new method of biochemical "brain-mapping". In this manner we can detect, for instance, transneuronal transfer of possible *trophic* substances in the central nervous system[5] and the differential up-take of steroids by various portions of the brain. This work has underlined the importance of temporal lobe structures in regulation of both cortical and estrogen function. These techniques may also further our knowledge of the metabolism of metal in the brain. Copper, lead, tin, mercury, manganese and lithium all have been linked to certain changes in brain and mental function. The recent work showing amelioration or control of manic-depressive states by administration of lithium carbonate indicates that investigation along these lines should also be rewarding.

Understanding of these biochemical-neural circuits could be important not only for a better understanding and therefore therapy of the usual run of mental and emotional illnesses, but also for those unfortunates plagued by life-long psychosomatic symptoms. The latter too often have been tossed off by our psychiatric brethren as being purely psychogenic in origin. Perhaps so, but it does seem that such symptoms may be truly organic in the sense that they become embedded in brain circuits as part of a self-inflicted conditioned reflex. (And at this point I must confess parenthetically that there is a very thin line between what some would call a psychogenic and others an organic pattern.) The main point to be made, I suggest, is that most psychosomatic complaints relate to the autonomic nervous system: stomach aches, anorexia, palpitations, sweating, a dry mouth, fatigue, constipation and perhaps sundry aches and pains including headache. Too little attention has been paid to a possible organic aetiology of such symptoms. Recent studies have shown that rats have so slowed their heart that they actually died of cardiac arrest. These and other experiments[3], indicating that cerebral control and conditioning is possible for *autonomic* nervous functions, suggest that psychosomatic complaints may likewise have become ingrained, conditioned reflexes. Experimental mapping of the involved circuits could, in the future, perhaps lead to specific stereotaxic method of relieving severe psychosomatic symptoms.

And finally, with reference to what Bell (1816) called hypochondriacs, which I suspect were often what we would call "psychosomatic" patients, he wrote as follows:[1]

> "In the Hypochondriac's feelings all is not imagination. Pains and odd sensations, attributable to external and remote parts, do actually proceed from the disturbance of internal nerves."

I would heartily second these prophetic remarks and suggest pursuit of brain mapping with this in mind. For it is clear we do not begin to know all we should about the nervous system. My orthopedic colleague, Professor Andrew Bassett, and others[2] have, for example, discovered that the internal as well as external parts of all bones of the body, including every Haversian canal, have a nerve supply. Where do these nerves go and what is their purpose? Is their role sensory, metabolic or perhaps trophic? Do they, like other nerves, enjoy cortical representation? Could it be, as your Dr. William Cullen (1710-1790) taught in 1760, that the normal state of the body is determined by "nervous energy" from the nervous system and affected by external stimuli[11]? These are additional questions for the future.

There are many other topics one could cite that need attention in the future. Suffice it

to say in closing that some of the more important include microsurgery to improve the circulation of the diseased brain; a better understanding and hence better treatment of some of the still mysterious forms of *hydrocephalus*; and perhaps the development of special techniques[7,8] or even implanted micro-electrical circuits fitted with miniature computers, to enable paraplegics to walk, and, as some are already attempting, to enable the blind to see.

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