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History

# E. Graeme Robertson – dynamics in fluid and light

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ABSTRACT

An eponymous lecture at the Australian and New Zealand Association of Neurologists Annual Scientific Meeting commemorates E. Graeme Robertson (1903–75), and some neurologists will know that particular Australian practices in clinical neurology, so far as they exist, have origins in his career. This is a historical article on the literary record of a man who had his own sense of history – an affinity with the past as well as an awareness of future generations of readers. He wrote authoritative texts on pneumoencephalography before new technology made it obsolete, and he produced a series of books on decorative architectural cast iron in Australian cities. A talent for visual interpretation seems to have drawn him to both of these topics; a common theme is contrast between light and dark, which is expatiated in images and in clear, well-written prose in his publications. We review his medical writings, including some largely forgotten principles of cerebrospinal fluid physics that he discovered when researching pneumoencephalography. We also explore his obsession with cast iron – its architectural historical significance, his techniques for photographing it, and some of the ways that it related to his life's work as a clinical neurologist.



## 1. Introduction

E. Graeme Robertson's name is familiar because of the eponymous memorial lecture at the Australian and New Zealand Association of Neurologists Annual Scientific Meeting. From preliminary comments by various speakers over the years, many will know that he was one of the first generation of Australian neurologists, that his articles and monographs on pneumoencephalography achieved a level of authority on the topic before new technology superseded this procedure, and that he produced a series of books on decorative architectural cast iron in Australian cities. Although it is a long time since he ceased to practice, records of his professional work in his home city of Melbourne occasionally surface when consulting on an older patient with a chronic neurological disorder. They show that he was an astute, disciplined clinician who liked to recount a case history in a free narrative style incorporating direct quotation of key symptoms. It is the purpose of this article to re-evaluate his literary accomplishments, both neurological and non-medical, and to trace some of the links between them. Most neurologists are good observers, but Robertson possessed something more – an artist's talent to see. Contrast between light and shadow was the theme that linked the pneumoencephalography work and his architectural photography, and to both he brought a characteristic persistence and perfectionism.

The official history of the Australian Association of Neurologists, *The Flowering of a Waratah*, contains a summary of his life and career.[1] Graeme Robertson was born in Melbourne in 1903 and graduated from the University of Melbourne in 1927. After travelling to London in 1930, he trained in clinical neurology at the National Hospital, Queen Square, and he worked on clinicopathological and neurophysiological research. Four years later he returned to Melbourne, where he practiced for the remainder of his career. He died, aged 72, in 1975. Mervyn Eadie's biographic sketch reflects on the fact that, by the end of his life, Robertson must have realised that his learning and proficiency in pneumoencephalography were quickly being outdated by better imaging techniques. But he had a posthumous literary output when his daughter co-authored several more books of his architectural photography, which achieved sizable circulations.

## 2. The medical writings of E. Graeme Robertson

The articles on the neural control of micturition and defaecation, written during his time at the National Hospital in the early 1930s, contain some of his best-remembered scientific research. This work was done in collaboration with Derek Denny-Brown (1901–81). The relative contribution of each of the two authors is hard to establish, but the New Zealander's experience in

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experimental physiology when working with Charles Sherrington (1857–1952) must have been an important ingredient. Two other factors promoted their investigations of the physiology of micturition. The first was a method for continuous recording of bladder pressures during various manipulations of bladder volume. The second was the researchers' use of themselves as subjects, leading to some precise observations about the operation of willed effort in the initiation and deferral of micturition. By careful correlation of introspection with pressure readings, they showed how the motor system operates across the interface between "voluntary" and "involuntary" control, using patterns of reciprocal activation and inhibition that involve both smooth and striated muscle activity.[2] Also in 1933 they published complementary research on impaired bladder control caused by lesions of the spinal cord at various levels and of the sacral nerve roots.[3] The article on the nervous control of defaecation was published two years later, and Robertson and Denny-Brown took some of the principles that they had established for bladder control as a starting point for an analysis of the relationship between rectal and anal sphincter muscle activity, and of the patterns of contraction of smooth and striated anal sphincter muscles.[4] The roles of local, spinal and supraspinal neural pathways were studied in patients with lesions affecting the cauda equina and spinal cord. Rectal and sphincteric pressure measurements were integrated with observations on willed effort and sensation to infer the mechanisms of normal voluntary control. Judging from similarities to the diagrams that appeared in his books on pneumoencephalography, the superior artwork in these papers was Robertson's. The micturition research taught him about fluid pressure in biological systems, and he later applied some of this knowledge to intracranial fluid physics.

Robertson wrote two clinico-pathological papers on subarachnoid haemorrhage from cerebral aneurysm.[5,6] The first, written in 1936, uses the Old Testament story about the Shunammite woman's son as its epigraph:[5]

> And he said unto his father, My head, my head ... and brought him to his mother, he sat on her knees until noon, and then died. 2 Kings 4.19–20.

He quotes the same ominous exclamation from several of his patients at the moment of aneurysm rupture. In his 1949 article, Robertson was the first author to present evidence for the occurrence of cerebral vasospasm after subarachnoid haemorrhage. Diffuse angiographic cerebral vascular spasm after bleeding from cerebral aneurysms was not described until 1951,[7] although animal experiments had shown that spasm of large and small cerebral arteries could be induced by electrical or mechanical stimulation.[8,9] Robertson correlated patterns of clinical deficits with pathological localisation of cerebral ischaemic damage, aneurysms, and the distribution of subarachnoid and intracerebral bleeding to propose that ischaemic lesions were caused by vasospasm induced by blood clot in the subarachnoid space. He noted that spasm could cause ischaemia in vascular territories remote from that of the vessel bearing the aneurysm, and that cerebral deficits caused by ischaemia were hard to differentiate from those caused by bleeding into the brain. These were very significant findings in an era when successful aneurysm surgery relied on clinical localisation supported by primitive angiograms.

Robertson's publications on pneumoencephalography started in 1941 with a small monograph.[10] In 1957, he published *Pneumoencephalography*, which soon became the standard reference text for neurologists, neurosurgeons and radiologists.[11] Pneumoencephalography had first been performed by Dandy in 1918.[12,13] While many practitioners later contributed refinements to the method, Robertson's system of controlled fractionated introduction of air was generally acknowledged to be the best. He developed this technique through careful observations and inquiry into the anatomy and hydrostatics of the cerebrospinal fluid (CSF) spaces. Sections on theoretical considerations precede those on technique and diagnostic applications in virtually all of his works on pneumoencephalography. This largely forgotten research discovered some principles that govern intraventricular pressure and ventricular size.

The whole pneumoencephalography technique depended on controlling the passage of air into the ventricular system by varying the rate of its introduction and the tilt of the head in the sagittal plane. With the subject in a sitting position with the head flexed, air, having been injected into the lumbar CSF, rises to fill the cisterna magna and is able to gain access to the fourth ventricle. But from this point, the buoyancy of the air and the resultant displacement of CSF cannot easily explain the rapid transit of air into the third and lateral ventricles. The aqueduct seems too narrow to allow for contraflow of an equal volume of CSF around the ascending bubbles or through a column of gas. With the head in partial flexion, air would actually move downwards into the anterior third ventricle – which sits below the level of the aqueduct –implying a positive filling pressure. He pointed out that air behaves in exactly the same way in cadavers, and that these effects were thus not explained by changes in blood volume or by pulsatile blood flow.[14] To solve this problem, he commissioned a glass model of the ventricular system, which was filled with water and placed in a bell-jar. Glass side-tubes and taps allowed him to vary the physical properties of the system. He found that air would not pass into the lateral and third ventricles of his model unless the spaces representing both the ventricles and the extracerebral subarachnoid spaces were provided with some compliance by side-arms fitted with rubber diaphragms. As air entered the ventricles, the ventricular diaphragm would bulge out, while the convexity subarachnoid diaphragm was sucked inwards. He proposed that the cranial CSF spaces behave like a U-shaped tube, with a hydraulic balance between the two arms and some elasticity of the intervening brain tissue (Fig. 1). The introduction of air into one arm reduces the mean density and thus the hydrostatic pressure developed by that fluid column, creating a pressure gradient. During pneumoencephalography, air is pushed into the upper ventricles, which expand to accommodate it (Fig. 2). Displacement of some fluid then resets the intraventricular pressure. The operator, by intermittently injecting

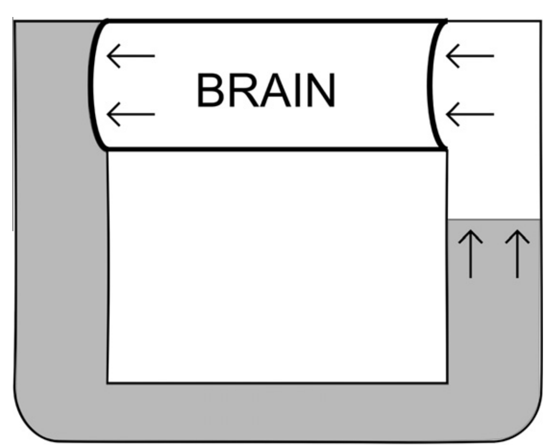


**Fig. 1.** A diagram representing E. Graeme Robertson's explanation of ventricular filling with air during pneumoencephalography in the upright posture. Since static fluid pressure is directly proportional to fluid density, replacement of some cerebrospinal fluid by air in the ventricular column (right) creates an imbalance between the two arms of this diagram. The resultant hydraulic force pushes air upwards through the ventricular system. Elasticity of the cerebral substance allows the lateral ventricles to expand to accept air before fluid has been displaced. (P. A. Kempster).