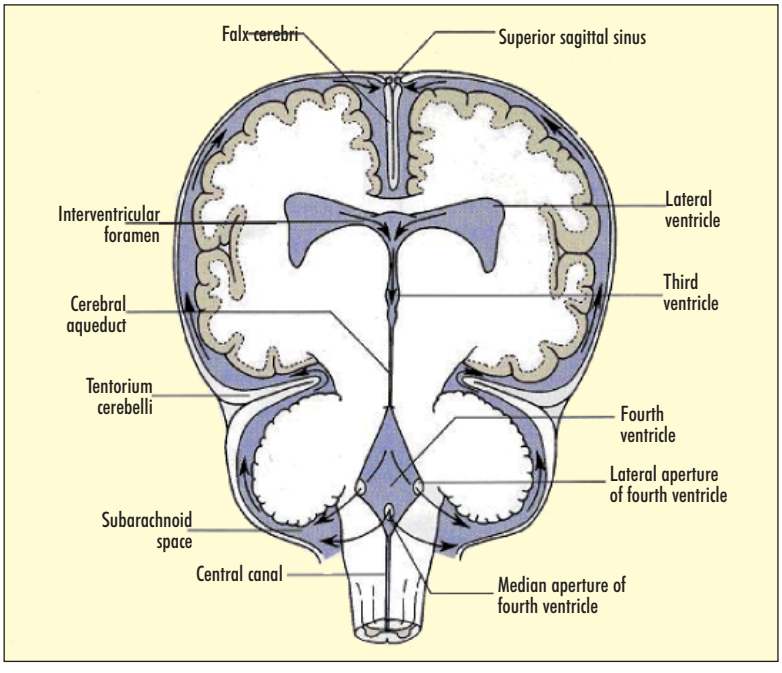
Pitfalls in the diagnosis of hydrocephalus

Hydrocephalus is a life-threatening condition presenting with a wide range of symptoms to a variety of specialties. Resulting delays in diagnosis can be hazardous. Doctors in all specialties should be familiar with the protean presentations of hydrocephalus.

Hydrocephalus, recognized by Hippocrates and Vesalius, and known colloquially as 'water on the brain', is defined as an excessive accumulation of CSF within the brain and cranial cavity (Laurence, 1993). CSF is produced primarily by the choroid plexuses located in the lateral, third and fourth ventricles of the brain, with some contribution from brain interstitial fluid (Bradbury, 1993). In the normal brain, the CSF flows through the ventricular system and escapes via the fourth ventricle (through the foraminae of Luschka and Magendie) into the subarachnoid space surrounding the brain and spinal cord. CSF is then reabsorbed into the venous system via the dural sinuses, principally the superior sagittal sinus located above the falx cerebri. Arachnoid villi project through the arachnoid and dura mater into the sinus itself, allowing drainage of CSF from the ventricular system. Villi are also present in the spinal dura and in other areas surrounding the brain (*Figure 1*).

Figure 1. The cerebro-ventricular system.



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Hydrocephalus may result from an excess of CSF production or an impairment of flow or absorption, leading to a transient or permanent increase in intracranial pressure. This forms the basis for one classification of hydrocephalus. Alternative classifications are based on anatomy (communicating *vs* non-communicating; Dandy and Blackfan, 1914) and aetiology (congenital *vs* acquired) (*Table 1*). Hydrocephalus is classified as communicating or non-communicating (ventricular) according to whether the excess CSF passes freely into the subarachnoid space or not. Lumbar puncture should be avoided in non-communicating hydrocephalus because of the risk of coning.

The most likely aetiological factors vary with the age of the patient and the rate of onset of the hydrocephalus. Once recognized, hydrocephalus is often amenable to surgical treatment, although a range of complications can arise.

Illustrative case reports

The following case reports illustrate, from local experience, that delayed diagnosis of hydrocephalus may result in adverse outcomes, including long-term gait disturbances, blindness, and even death. This review discusses the current literature on this topic and highlights the importance of awareness of the condition.

Table 1. Classification of hydrocephalus

Communicating	↓ absorption	Meningo-encephalitis (especially bacterial)
		Subarachnoid haemorrhage
		Normal pressure hydrocephalus
		↑ Venous sinus pressure (e.g. thrombosis)
	↑ production	Choroid plexus papilloma
	Idiopathic	
Non-communicating	Congenital	Aqueduct stenosis
		Chiari malformations 1 and 2
		Agenesis of Foramen of Munro
	Acquired	Space-occupying lesion – tumour, abscess, arteriovenous malformation

Case 1: Delayed presentation of headache

A 13-year-old girl had a 2-year history of mild but frequent morning headaches, sometimes associated with vomiting. They responded to simple analgesia and did not interfere with her fine academic and sports performance at school. She presented to her GP with a 1-day history of severe, unrelenting headache accompanied by vomiting and irregular breathing. On transit to hospital she had a cardiorespiratory arrest. Cardiac output was restored with external cardiac massage and the patient was intubated and ventilated. On arrival in the intensive therapy unit she was unresponsive to pain and had fixed, dilated pupils. Computed tomography (CT) scanning showed marked, symmetrical dilatation of the third and lateral ventricles with an unidentifiable fourth ventricle. Skull X-ray showed extensive scalloping of the skull vault and diastasis of the major sutures consistent with chronically raised intracranial pressure. Brainstem death was confirmed and organ harvesting performed. Post-mortem revealed aqueduct stenosis and an oedematous brain with tonsillar herniation and agonal necrosis of the upper brainstem.

Case 2: 'Hysterical blindness'

A 10-year-old girl presented to her GP with a 2-week history of occipital headache associated with vomiting. The headaches were felt to be migrainous. She mentioned difficulty with distant vision. An optician was unable to find a refractive error. Returning to the GP 2 months later, her headaches continued and she reported a decline in her visual acuity, affecting her schoolwork. At assessment by an ophthalmologist her acuities were 'extremely variable'; she was mildly hypermetropic. The optic fundi were normal. 'Functional' or 'hysterical' visual loss was suspected.

Six months later, worsening of her visual symptoms and persistent headaches prompted GP referral to a paediatrician. She was no longer able to read or watch television, stumbled over objects in the street and had difficulty identifying faces. On examination, the pupils were dilated and poorly responsive and the optic discs were bilaterally pale. There was vertical and horizontal nystagmus. A magnetic resonance imaging (MRI) brain scan revealed grossly dilated third and lateral ventricles with a normal-sized aqueduct and fourth ventricle, consistent with congenital aqueduct stenosis. The third ventricle had herniated inferiorly, compressing the optic chiasm. Open drainage was performed followed by placement of a ventriculo-peritoneal shunt. The headaches subsequently disappeared but, unfortunately, there was little improvement in the patient's visual acuity.

Case 3: Longstanding neurological symptoms with bladder disturbance

A 21-year-old man had a longstanding history of urinary frequency, urgency and nocturia. A urethral stricture was treated surgically but the urologist also noted the patient to have lower limb spasticity and referred him to the neurological services. It emerged that, ever since primary school, the patient had suffered from intermittent headaches, a poor memory and slowly progressive 'clumsiness'. On examination, the head circumference was 61 cm (3 cm above the 97th centile). Tone in the legs was increased with brisk reflexes and an extensor left plantar. Gait and sitting balance were unsteady. The Mini Mental State Examination was normal. A CT head revealed marked hydrocephalus of the third and lateral ventricles in keeping with aqueduct stenosis. There was considerable loss of parietal and cerebellar parenchyma. A ventriculo-peritoneal shunt was inserted. There has been no further progression of the ataxia, memory trouble or urinary symptoms but the postoperative course was complicated by a shunt infection and subdural haematoma.

Case 4: 'Refractory depression'

A 77-year-old woman became progressively withdrawn over the course of several months following minor surgery. Depression was suspected by her GP, and later by a psychiatrist, but she did not respond to antidepressant treatment. Although a CT scan showed somewhat dilated ventricles, the cortical mantle appeared normal and the ventricular dilatation was not considered significant. The patient became stuporose, was admitted under the psychiatry service and treated with electroconvulsive therapy, with no improvement. Neurological assessment was difficult but revealed hypertonia and possibly extensor plantars. A lumbar puncture showed a CSF protein of 1.8 g/litre, and an MRI scan of the brain showed a meningioma at the foramen magnum. The tumour was thought to be causing hydrocephalus by elevation of CSF protein and interference with CSF reabsorption. The meningioma was removed and after some months she returned to her normal, independent existence.

The presenting features of hydrocephalus

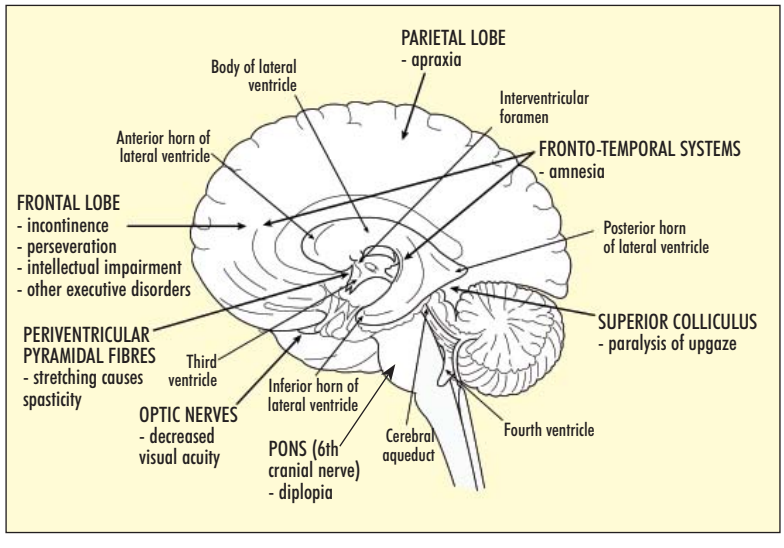
The symptomatology of hydrocephalus is dependent on the nature of the underlying cause and in particular the tempo of onset. Classical features of raised intracranial pressure, headache and vomiting, are conspicuous among patients with acute hydrocephalus secondary to a cerebral event such as subarachnoid haemorrhage and with shunt malfunction. However, these symptoms are significantly less common among patients with chronic hydrocephalus developing over months to years. This is reflected in the significant delay to diagnosis of more chronic cases, illustrated by the case reports. An audit of 125 patients, over the age of 16 years, referred to the authors' department between 1999 and 2004 for the investigation and treatment of hydrocephalus, confirmed the previously noted tendency for chronic hydrocephalus to present with gait disturbance, cognitive symptoms and incontinence (T Ambrose, A Zeman, unpublished observations, 2005).

The symptoms of chronic hydrocephalus (*Figure 2*) are thought to be caused by distortion of white matter tracts by the expanding ventricular system. Gait disturbance is common, occurs early and results either from parietal injury causing apraxia or from spasticity as periventricular lower limb pyramidal fibres are stretched (*Case 3*). The step is often shortened, the gait appears clumsy and falls are frequent. Cognitive impairment, especially memory problems, slowing of mentation, inattentiveness, perseveration and other executive disorders are thought to indicate compression of medial temporal and frontal lobe projections by the expanding ventricular system (Davson et al, 1987) (*Case 3*). Similar mechanisms underlie incontinence of urine or faeces, particularly associated with normal pressure hydrocephalus, to which the patient often appears indifferent. In extreme cases, hydrocephalic dementia can lead to a stuporose state (Jeffreys, 1993) (*Case 4*). Other psychiatric presentations may occasionally be symptomatic of hydrocephalus: a case report (Reisch et al, 2005) suggests a link between undiagnosed hydrocephalus and bipolar disorder, the latter improving greatly after treatment of the hydrocephalus.

Visual impairment, illustrated by case 2, is an important, although probably less frequent, complication. Decreased visual acuity can be associated with papilloedema or optic atrophy. Diplopia can occur as a 'false localizing' lateral rectus palsy as the sixth cranial nerve is stretched. Pressure on the superior colliculi and tectum may lead to a failure of conjugate upward gaze. Hypopituitarism is another infrequent but important consequence of chronic hydrocephalus, resulting from compression of the pituitary gland against the sella turcica by an expanding third ventricle.

The authors' findings complement those of Cowan et al (2005) who proposed that hydrocephalus in patients between the ages of 16 and 55 years tends to present with a distinctive constellation of symptoms, contrasting somewhat with hydrocephalus in children and elderly (the syndrome of hydrocephalus in young and middle-aged adults, SHYMA). The most frequent symptoms in their study were gait disturbance, cognitive problems, urinary urgency and headaches. The signs and symptoms in this age group were unrelated to the cause of the hydrocephalus.

Figure 2. Areas of the brain affected by hydrocephalus (in capitals) and their clinical manifestations.



Delayed diagnosis of more chronic cases

In the authors' audit, the average delay to presentation to a professional in secondary care was over 1 year in patients with symptoms of chronic hydrocephalus. Initial referrals were to a variety of clinical specialities including neurology, medicine of the elderly, psychiatry and ophthalmology. Only one third of the authors' patients were referred directly to neurosurgery for definitive treatment. Cowan et al (2005) recorded even longer delays, with a mean delay to diagnosis of 6 years, reporting a case of a poor outcome after two decades of untreated symptomatic hydrocephalus. Of importance, it has been proposed that hydrocephalus may, over time, become 'intractable' or non-treatable by surgical shunting (Mori, 2000). Furthermore, Robertson et al (1990) have suggested that lengthy delays to diagnosis among patients with chronic aqueduct stenosis are associated with an increased rate of treatment complications and even death. The authors' study confirmed that the longer the time to intervention, the higher the likelihood of persisting symptoms.

The importance of early recognition of hydrocephalus is underlined by evidence that hydrocephalus is the second most common potentially reversible cause of dementia in all ages (Hejl et al, 2002). Neuropsychological assessment suggesting features of 'subcortical dementia', in particular slowing of thought, forgetfulness and executive dysfunction, can help to suggest the diagnosis (Devito et al, 2005).

Investigation and treatment of hydrocephalus

The primary investigation remains brain imaging, usually CT scanning in the first instance (*Figure 3*). *Case 4*, in which ventricular dilatation was attributed to normal ageing, illustrates that the interpretation of CT findings is not always straightforward. MRI may help to delineate the cause but it is inadvisable to allow a long waiting list for MRI to delay the diagnosis. Macrocrania, skull vault thinning and 'scalloping' may be seen in chronic cases (*Case 1* and *Figure 3b*). The temporal and frontal horns of the lateral ventricles dilate first, often asymmetrically. Ballooning of the frontal horns and third ventricle ('Mickey mouse' ventricles) indicates aqueductal obstruction. The sylvian and interhemispheric fissures become obliterated. Transependymal absorption in acute hydrocephalus is seen as periventricular low density. The corpus callo-

sum may bow upwards in acute hydrocephalus, or become atrophied in the more chronic case – a sign best appreciated on sagittal MRI. Lumbar puncture can be of value both in elucidating the causes of communicating hydrocephalus, and in treatment (Malm and Eklund, 2006) but is contraindicated in obstructive hydrocephalus and requires specialist advice.

Surgical treatment can undoubtedly benefit patients with hydrocephalus, but complications (particularly secondary subdural fluid collection, shunt failure and infections) sometimes ensue, and the potential risks and benefits of intervention should be discussed openly before treatment. *Figure 4* proposes an algorithm for the general hospital practitioner to aid in the diagnosis and further management of patients suspected of having hydrocephalus.

Conclusions

Hydrocephalus can present with classical features of raised intracranial pressure, but also with more subtle impairments of gait, cognition, alertness, continence and vision. Patients with symptoms caused by hydrocephalus are referred to a variety of medical and surgical specialties and to psychiatrists. Widely available CT scanning can rapidly exclude the diagnosis. Long delays to diagnosis carry a risk of irreversible sequelae, including death. **BJHM**

Figure 1 *is reproduced from Crossman and Neary (2000) by kind permission of Elsevier.*

Conflict of interest: none.

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Figure 3. a. Acute hydrocephalus: axial computed tomography at the level of the lateral ventricles demonstrating ventricular enlargement and periventricular low density as a result of transependymal CSF migration into white matter. b. Chronic hydrocephalus: axial computed tomography at the level of the lateral ventricles demonstrating marked ventricular enlargement with skull vault thinning and scalloping.

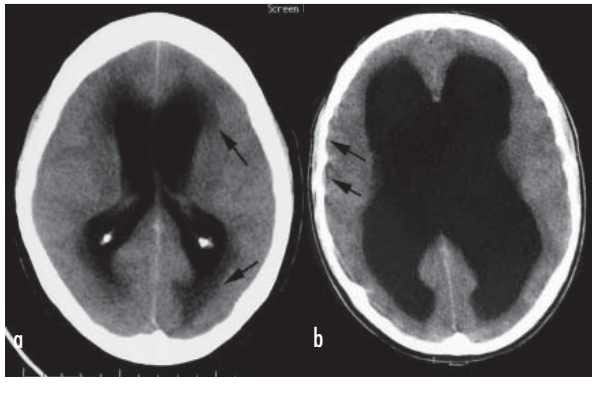
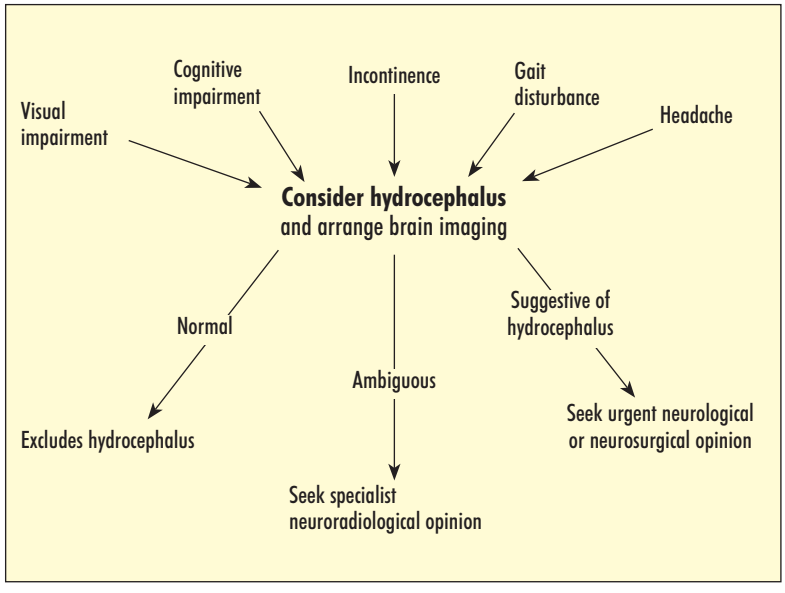


Figure 4. An algorithm for the diagnosis and management of hydrocephalus.



KEY POINTS

- Hydrocephalus presents with a wide variety of symptoms including headache, nausea and vomiting, gait disturbance, visual and cognitive impairment, and urinary incontinence.
- Diagnosis of chronic hydrocephalus, associated with an insidious onset of symptoms, is often delayed.
- Delayed diagnosis of hydrocephalus risks long-term morbidity, and sometimes death.
- Computed tomography scanning rapidly excludes hydrocephalus.
- Practitioners in all branches of medicine should be aware of the disorder.