Cranial neuroimaging

Incidental findings and their significance

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In recent years, advances in neuroimaging have led to an increase in the detection of incidental brain abnormalities, ranging from anatomical variants to lesions requiring specialist referral. To ensure appropriate management, it is important for GPs to have a basic understanding of these common conditions.

Incidental findings in this article are defined as unexpected results or asymptomatic anomalies discovered through radiological investigations completed for other purposes. In modern medical practice, the use of imaging, such as CT and MRI, has become commonplace.

Advances in technology have improved the accessibility of brain imaging, leading to an increased detection of anatomical variants, benign conditions and pathological lesions. Patients are often informed about the implications of these findings and advised on subsequent management by their primary care physician. Although not an exhaustive list, this article discusses the most common incidental findings and outlines their management approaches.

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Incidental findings in children

MRI is a key diagnostic tool in paediatrics, often used to investigate symptoms such as persistent headaches with nausea or vomiting, seizures or abnormal neurological signs. Owing to radiation risks, CT use in children is typically limited to the evaluation of head trauma. Incidental findings have been identified with both CT and MRI.[1]

Furthermore, incidental findings have been reported during screenings for other syndromes, such as metabolic disorders, or in healthy volunteers during research studies.[2] Increasingly, children receive scans as part of assessments for developmental delay, autism spectrum disorder, behavioural regression or learning difficulties.[3] The discovery of incidental findings during these screenings may cause anxiety among patients and practitioners about the potential implications of such findings.

KEY POINTS

- The detection of incidental brain findings has increased in recent years following the expanded availability of advanced neuroimaging techniques.
- Incidental findings may cause uncertainty among GPs regarding appropriate management, in addition to significant anxiety and distress for the patient and their family.
- Although many incidental findings are benign and require no specific management, others necessitate follow up with repeat neuroimaging or specialist referral, or both.
- Indications for neuroimaging in children include progressive headaches with nausea or vomiting, seizures and the presence of abnormal neurological signs.
- Common incidental brain findings include meningiomas, arachnoid cysts, pituitary cysts, pineal cysts, developmental venous anomalies, low-grade tumours and T2 hyperintensities.
- GPs play an important role in identifying when follow up or specialist referral is necessary.

Studies show that incidental findings occur in about 26% of paediatric brain MRIs.[4] Most are benign and include arachnoid cysts, Chiari I malformations, pineal cysts, enlarged perivascular spaces or minor white matter changes. Only a small fraction are clinically significant or require intervention. Despite their benign nature, these findings can cause distress among families and lead to further testing, referrals and, in some cases, overtreatment.[5]

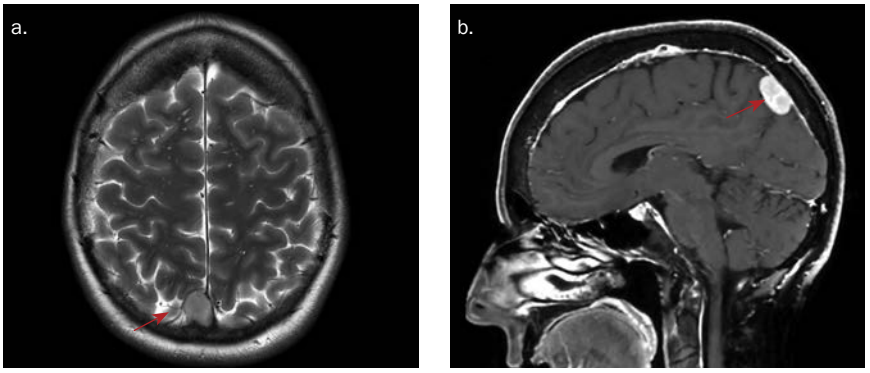
Ultimately, the primary care physician must determine whether the findings necessitate referral for specialist review, the urgency of such referral and the need for any additional investigations. Moreover, some of these findings might require long-term follow up or procedures that may have inherent risks. This article aims to help guide some of these conversations between primary care physicians and their patients.

Meningiomas

Meningiomas are one of the most common cranial imaging incidental findings in adults, occurring in about 1% of the general population.[6] They are more common in women and increase in prevalence with age.[7] They are often located over the convexity of the brain and may have features consistent with heavy calcification. Small lesions (<15 mm) with typical features, such as a smooth, rounded appearance with a dural tail and underlying hyperostosis of the skull, can be confidently concluded to be meningiomas (Figures 1a and b).[8]

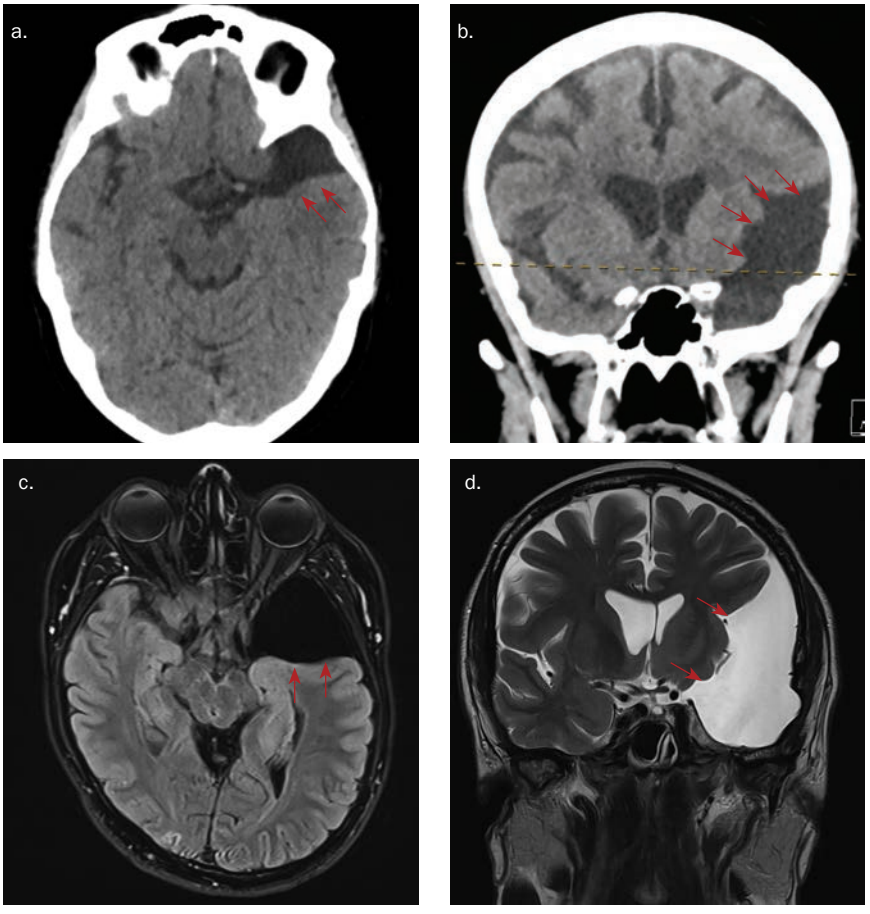
In older patients, in the absence of other comorbidities such as malignancy, no further follow-up imaging may be necessary. In younger patients, or when the diagnosis is uncertain, follow-up imaging should be performed. MRI with gadolinium is preferable in these circumstances, initially at six months and then annually. If the results remain stable, the interval between imaging may be further increased and eventually ceased altogether. Larger lesions, particularly in more sensitive locations such as the posterior fossa, should be referred for a neurosurgical opinion and followed up with repeat imaging.[9]

Most incidental meningiomas remain stable and do not require surgical intervention, given their prevalence and typically



Figures 1a and b. Axial T2-weighted MRI of a right parasagittal meningioma (a, left) and sagittal T1-weighted gadolinium-enhanced MRI of a parasagittal meningioma (b, right).
Abnormalities are indicated by red arrows. Images courtesy of the authors.

slow growth. However, larger asymptomatic tumours may warrant surgery to prevent future neurological complications. Fortunately, the vast majority can be removed safely with minimal neurological sequelae.[10]



Figures 2a to d. Axial CT scan (a, top left), coronal CT scan (b, top right), axial fluid-attenuated inversion recovery MRI (c, bottom left) and coronal T2-weighted MRI (d, bottom right) of a left middle cranial fossa arachnoid cyst.
Abnormalities are indicated by red arrows. Images courtesy of the authors.

Arachnoid cysts

Arachnoid cysts are a common incidental finding on brain imaging in children and adults. These cysts arise early in development, which is often evident by the way the brain forms around the cyst and by the absence of symptoms, even though these cysts may be very large. Their size often creates anxiety and an expectation that neurosurgical treatment will be required. However, the majority require no treatment or follow up.[11]

The most common location for an arachnoid cyst is the middle cranial fossa (Figures 2a to d). Cysts with significant mass effect are uncommon but may require surgical fenestration or shunting. Occasionally, patients may present with rupture of a cyst or even haemorrhage into a cyst, which is sometimes related to head trauma. Patients may be advised to avoid contact sports to reduce the risk of cyst rupture; however, the actual risk of rupture is not currently known.[12] Retrocerebellar cysts are rarely symptomatic, and they seldom require treatment (Figures 3a and b).

Mega cisterna magna

Characterised by an enlarged cisterna magna, intact cerebellar vermis and the absence of hydrocephalus, mega cisterna magna (defined as a cisterna magna >10 mm) is an asymptomatic anatomical variant and an incidental finding on neuroimaging. It requires no specific follow up or management. The mega cisterna magna exerts no mass effect on the fourth ventricle or cerebellar vermis, distinguishing this condition from an arachnoid cyst.[13]

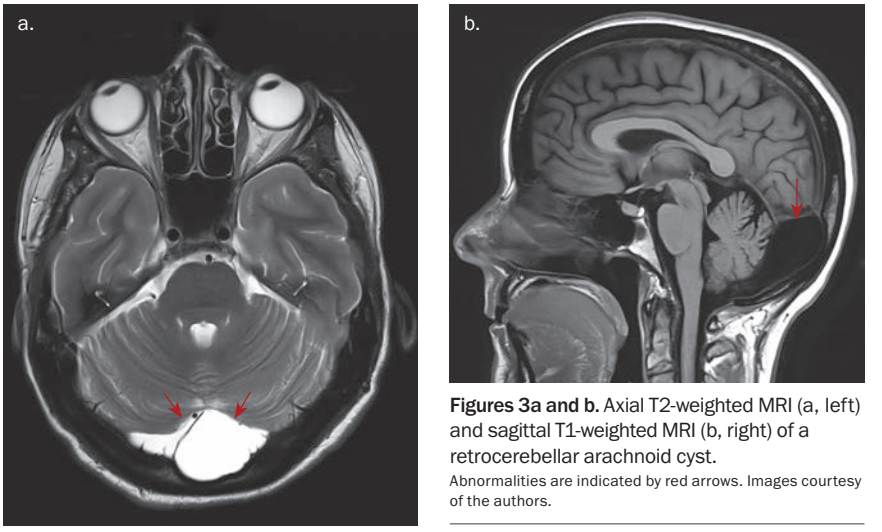
Pituitary lesions

The prevalence of pituitary lesions increases with age. Pituitary lesions are normally benign, with pituitary adenomas or pituitary cysts being the most common. Some lesions may be more complex, such as craniopharyngiomas. Pituitary function tests are required as further work-up of pituitary lesions. Small pituitary adenomas, which are nonfunctional and not

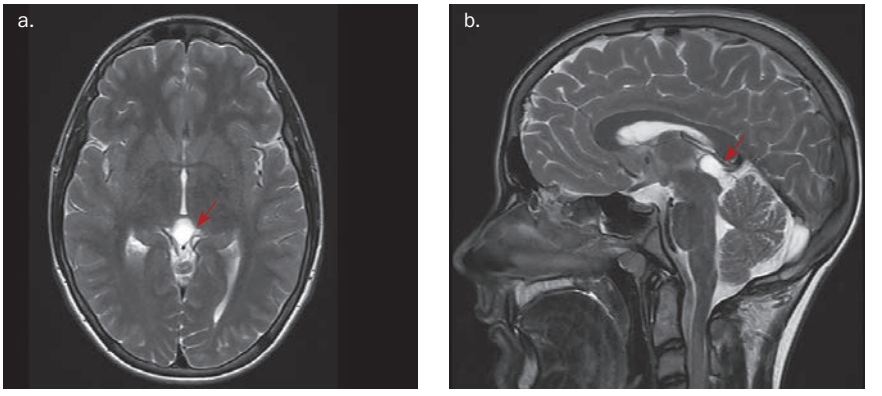
hormone-producing, are common, as are small, simple cysts. Rathke's cleft cysts also occur in the pituitary gland and may be incidentally identified on imaging. Endocrinological assessment, neurosurgical referral and radiological surveillance may be required for some of these lesions. Larger lesions that encroach on the optic chiasm may require closer surveillance or even surgical treatment if there is concern about the potential future impact on visual function.[14]

Pineal cysts

The pineal gland is largely a remnant of evolution in humans. Many different tumours can occur in the pineal region. Aggressive lesions are most often diagnosed because of symptoms, such as headaches, due to local mass effect or obstruction of the aqueduct causing hydrocephalus. Pineal cysts, however, are quite common. They are normally small simple cysts with no or minimal peripheral contrast enhancement. They do not usually require treatment. In recent years, some have argued that simple pineal cysts are a cause of headaches, but this is rarely the case. Small, simple pineal cysts seldom require ongoing radiological surveillance.[15] Figures 4a and b present MRI scans of a pineal cyst.



Figures 3a and b. Axial T2-weighted MRI (a, left) and sagittal T1-weighted MRI (b, right) of a retrocerebellar arachnoid cyst.
Abnormalities are indicated by red arrows. Images courtesy of the authors.



Figures 4a and b. Axial T2-weighted MRI (a, left) and sagittal T2-weighted MRI (b, right) of a pineal cyst.
Abnormalities are indicated by red arrows. Images courtesy of the authors.

Colloid cysts of the third ventricle

Colloid cysts of the third ventricle warrant specific consideration. These lesions are histologically benign but can cause acute obstructive hydrocephalus, leading to rapid deterioration and unexpected death. In some cases, they are identified incidentally; however, even asymptomatic lesions require neurosurgical assessment and, at a minimum, close radiological surveillance.[16] A colloid cyst of the third ventricle is shown in Figure 5.

Chiari malformations

Chiari type I malformations are typically symptomatic between the ages of 25 and 45 years.[17] A Chiari malformation is a condition in which the cerebellar tonsils project through the foramen magnum. This descent can obstruct the normal circulation of CSF from the cranial to the spinal subarachnoid space.[18]

Symptomatic Chiari malformations are most commonly associated with headaches precipitated by coughing, stooping, sneezing or straining. There are also many other symptoms attributed to Chiari malformation.

In some cases, a Chiari malformation is present, but it may be uncertain whether the symptoms prompting the scan are related to the malformation itself.[19] Nonetheless, a neurosurgical opinion in these circumstances is often necessary. In the absence of other imaging findings, such as a syrinx, no treatment is usually

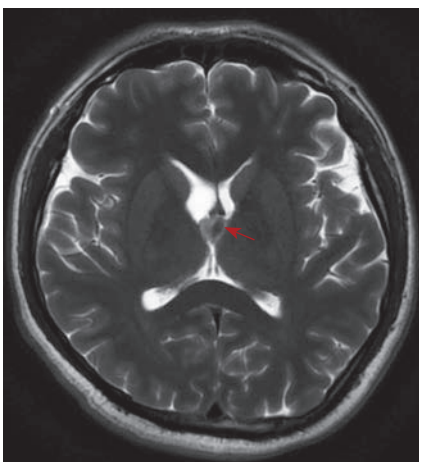
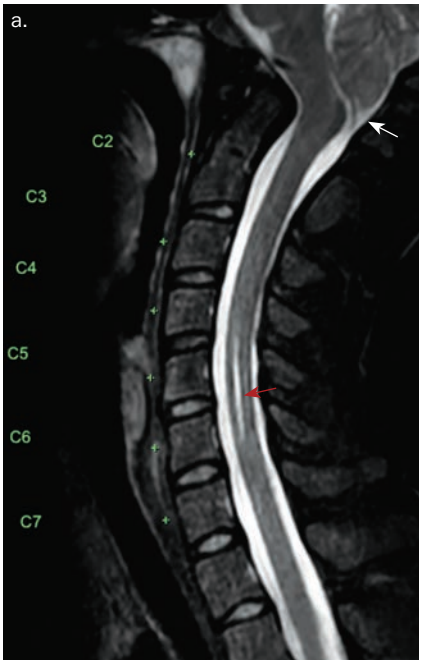
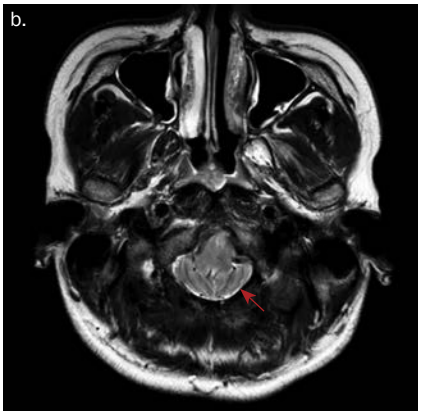


Figure 5. Axial T2-weighted MRI of a colloid cyst of the third ventricle.
Abnormality is indicated by red arrow. Image courtesy of the authors.





Figures 6a and b. Sagittal T2-weighted MRI of the craniocervical junction and cervical spine demonstrating a Chiari type I malformation (white arrow) and a small cervical syrinx (red arrow) (a, left) and axial T2-weighted MRI of the foramen magnum demonstrating crowding at the cervicomedullary junction (b, right).
Abnormalities are indicated by red and white arrows. Images courtesy of the authors.

required. Figure 6a shows a Chiari type I malformation and a small cervical syrinx, and Figure 6b shows crowding at the cervicomedullary junction of the foramen magnum.

Developmental venous anomalies

Developmental venous anomalies (DVAs), or cerebral venous angiomas, are one of the most common incidental findings on neuroimaging, with a prevalence of about 6%. DVAs are the most common cerebral vascular malformation, are usually asymptomatic and require no specific treatment. They are characterised by a number of smaller veins converging centrally into a single collecting vein, the so-called caput medusae. The majority of DVAs are supratentorial, with about 20% located in the cerebellum. These veins represent the only venous drainage pathway for the involved areas of the brain. Although the natural history is generally benign, DVAs may be associated with cerebral cavernous malformations (CCMs), increasing the risk of haemorrhage.[20] These may require further neurovascular assessment and radiological surveillance. A developmental venous anomaly is shown in Figure 7.

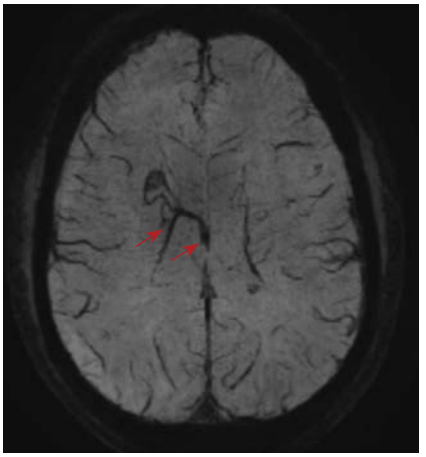


Figure 7. Susceptibility-weighted MRI of a right hemispheric developmental venous anomaly.
Abnormality is indicated by red arrows. Image courtesy of the authors.

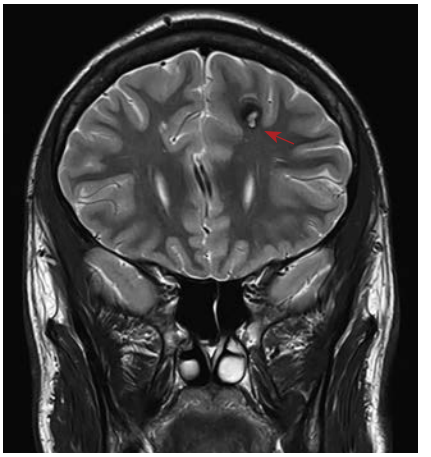


Figure 8. Coronal T2-weighted MRI of an incidental cerebral cavernous malformation.
Abnormality is indicated by red arrow. Image courtesy of the authors.

Cerebral cavernous malformations

With a prevalence of 0.16 to 0.5%, CCMs, or cavernomas, are composed of a cluster of abnormally dilated and hyalinised capillaries, with an appearance similar to a small mulberry. About 20 to 50% of CCMs are asymptomatic and are discovered incidentally on MRI. Such lesions are generally managed conservatively with follow-up MRIs.

Management of symptomatic lesions (i.e. seizures, haemorrhage, focal neurological deficits) is determined by a range of factors, including surgical accessibility, eloquence of surrounding brain tissue and the presence or absence of an associated DVA.[21] These will require neurosurgical review and follow up. An incidental CCM is shown in Figure 8.

Aneurysms

Aneurysms are potentially dangerous vascular lesions that are sometimes found incidentally on CT or MRI. Treatment may include craniotomy and clipping or, more commonly, endovascular treatment such as coiling. Not all aneurysms require treatment.

Management will be determined by a range of factors that balance the risk of rupture, causing subarachnoid haemorrhage, against the risks of potential treatment. Patient factors, such as age, family history and general health, and the features of the aneurysm, such as size, shape and location, are all relevant in decision-making.

Referral to a neurosurgeon with subspecialisation in vascular neurosurgery should be made to determine the

appropriate management. An urgent referral should be made if there is any concern that the aneurysm is symptomatic, an example being a third nerve palsy from a posterior communicating artery aneurysm. Sentinel headaches in which there is no evidence of haemorrhage sometimes occur when aneurysms are rapidly enlarging and may herald subsequent subarachnoid haemorrhage.[22]

Low-grade tumours and other intra-axial lesions

Most of the lesions described above have a typical appearance, and the diagnosis can be made confidently on CT or MRI. However, a common incidental finding is a lesion within the brain that may represent low-grade tumours, such as a lower-grade glioma. MRI typically shows a lesion that is hyperintense on T2-weighted images, hypointense on T1-weighted images and without gadolinium enhancement. The imaging report may describe a list of differential diagnoses, including low-grade glioma.

Diagnosis of these lesions is important because surgery may be the best option to prevent progression in the long term. However, the lesions must be differentiated from other lesions, such as demyelinating lesions, developmental anomalies or even other tumours. As such, they can represent a diagnostic dilemma and may require further assessment with other modalities such as positron emission tomography scanning or even biopsy. An assessment and follow up with a neurosurgeon is necessitated.

In many cases, neurosurgical review will be useful for patients with incidental findings on imaging. A neurosurgical opinion can establish the importance of the finding and whether follow up is required. Most neurosurgeons have well-established follow-up protocols for these pathologies. Providing education and reassurance for the patient and their family is an important part of neurosurgical practice; however, when GPs can offer guidance on some of the more common findings, it helps mitigate unnecessary anxiety before the neurosurgical review.[23]

T2 hyperintensities

T2 hyperintensities are another common finding on neuroimaging with a wide differential diagnosis. They have a prevalence ranging from 11 to 21% among those who are 64 years of age, and increasing to 94% among those who are 82 years of age. White matter T2 hyperintensities are thought to result from chronic hypoperfusion secondary to small vessel disease and are more common in patients with high cardiovascular risk.[24] White matter hyperintensities can be divided into deep white matter and periventricular hyperintensities; subcortical grey matter hyperintensities occur in the basal ganglia. Although often an incidental finding associated with ageing (leukoaraiosis), T2 hyperintensities, depending on the location, morphology and clinical correlation, may also be a sign of ischaemia or infarction, inflammation or demyelination (e.g. multiple sclerosis), vascular abnormalities (e.g. microangiopathies, venous infarctions) or infection (e.g. encephalitis).[25]

Conclusion

Advances in neuroimaging techniques and their widespread uptake in clinical practice have led to a substantial increase in the detection of incidental brain findings. Patients and their families may experience significant anxiety and distress in relation to such findings. These abnormalities may represent anatomical variants, benign lesions or true pathology that requires follow up or specific management, or both. Therefore, it is important that GPs have a basic understanding of the more common incidental findings from cranial imaging and are equipped to guide their appropriate management. MT

References

A list of references is included in the online version of this article (www.medicinetoday.com.au).

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