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How often is haemosiderin not visible on routine MRI following traumatic intracerebral haemorrhage?

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Abstract Intracerebral haemorrhage may be visible indefinitely on MRI, due to persistence of haemosiderin in macrophages around the lesion, but it is not clear whether all haemorrhages produce haemosiderin or, if not, what proportion cannot be identified as former haemorrhages on routine MRI. We performed routine MRI (spin-echo T2- and proton-density weighted images) in 116 survivors of moderate to severe head injury, 1–5 years after injury. We reviewed the images blindly and correlated them with CT in the acute stage, to determine how many haemorrhages from the acute stage were identifiable by virtue of haemosiderin deposition on late MRI. Of 106 haemorrhages in 78 patients on CT at the time of injury, 96 (90 %) were visible as haemosiderin on late MRI. Of the old haemorrhages without haemosiderin, seven of ten were in patients where another haemorrhage with haemosiderin was still visible elsewhere in the brain. No patient or haemorrhage features explained the formation or absence of haemosiderin. Thus about 10 % of definite haematomas show no trace of haemosiderin on routine spin-echo MRI. Radiologists should be alerted to supplement routine spin-echo with gradient-echo sequences if there is a reason to suspect, or specifically exclude, prior haemorrhage.

Key words Haemorrhage, intracerebral · Haemosiderin · Magnetic resonance imaging

Introduction

The features of intracerebral haemorrhage are said to be visible indefinitely, possibly for ever, on histology, because haemosiderin (produced following breakdown of haemoglobin) has a characteristic appearance and persists in cells in the walls of old haematomas [1]. For the same reason, previous haemorrhages are thought to remain visible indefinitely on MRI, due to the ferromagnetic effect of haemosiderin [2]. However, it is not clear whether these features do indeed persist indefinitely, and there does not appear to have been a study in which patients with proven primary intracerebral haemorrhage (PICH) were systematically recalled and scanned with MRI late after the bleed. We therefore studied a group of patients who had proven intracerebral haematomas due to head injury and then underwent routine (spin-echo) MRI a year or more after the injury in order to determine what proportion of old haematomas were definitely visible on routine MRI by virtue of haemosiderin deposition.

Materials and methods

We invited all patients from our inpatient head-injury registry who had survived to 1 year, and consented to be examined, to attend for MRI. Previous CT studies, and radiological reports (where the images were not available) were identified and reviewed.

We used a 1.0-T imager, obtaining a T1-weighted sagittal localiser and spin-echo T2- and proton-density (PD) -weighted axial images. The sequence parameters were: TR 3565 TE 20 and 90 ms 5-mm-thick continuous slices, acquisition time 11.29 min, 1 excita-

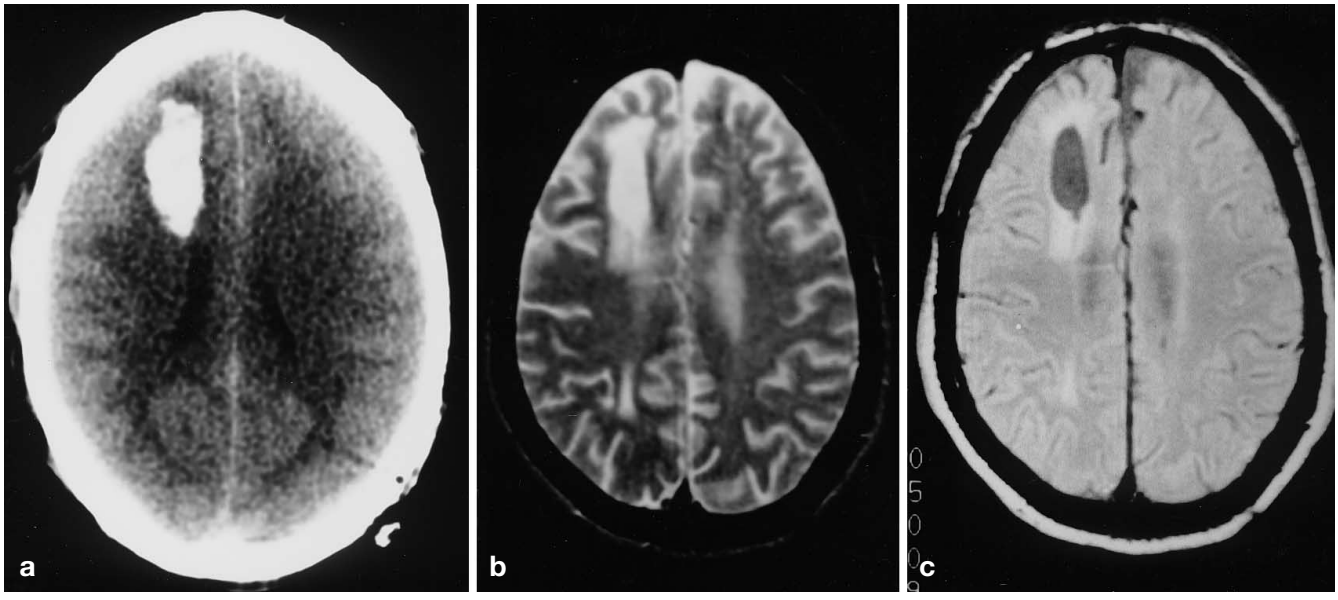

Fig. 1 a–c A large, sharp-edged, dense haematoma which "disappeared" **a** CT 4 h, **b, c** T2- and PD-weighted MRI 1 year after injury. Note that despite the size and density of the haematoma, (which is not unlike some spontaneous haemorrhages in appearance) there is no haemosiderin rim on late MRI

tion, matrix 192 × 256 for PD- T2-weighted images and TR 294 TE 6 ms, 5 mm slice thickness, 1 excitation, matrix 192 × 256, acquisition time 1 min for the localiser. The images were printed on film for reading.

The CT (from the time of injury) and the MRI (at 1 year or more) were reviewed twice. On the first occasion, the CT and MRI were placed side by side and any area of parenchymal haemorrhage (high density) on the CT was sought on the MRI as low signal (black) on T2- and PD-weighted images, indicative of haemosiderin. Flow voids were distinguished from haemosiderin by the difference in their appearance on T2- and PD-weighting: on the latter flow voids appear very black and haemosiderin less black, whereas on the former both appear equally black.

On CT, the following features of the haemorrhage were noted: site (right or left, frontal, parietal, temporal, occipital, basal ganglia, deep hemisphere white matter, brain stem or cerebellum); density (very dense or less dense, i.e., very white or less white); size: small (occupying less than half the relevant lobe) or large (occupying more than half the lobe); edge (distinct or blurred); and type: contusion or haematoma (somewhat arbitrarily defined as contusion if a patchy superficial area of mixed, increased density, and haematoma if a more uniform, dense, rounded area). The radiological report of the CT was used to identify the acute haematomas if the original study was missing. In this group, minor but not major haemorrhages may have been missed (i.e. not mentioned). Additional areas of haemosiderin not apparently related to haemorrhage on the early CT were also noted, as haemorrhage into contusions may develop during the acute phase of the head injury after performance of the CT.

On the second occasion, the MRI films were shown to a consultant neuroradiologist, blinded to all CT and clinical information, to identify areas of parenchymal haemosiderin deposition. The results of this second review were compared with the first. Any images where there was a discrepancy between the two were reviewed again and a consensus reached. There was a gap of about 3 weeks between the first and second viewings.

The data were entered into a database and combined with clinical data on the patients from the Head Injury Registry (age and sex, date of injury, time from injury to MRI). The data were analysed using simple descriptive statistics and *t*-tests.

Results

We carried out MRI on 116 patients (mean age 33 years, range 17–75 years). The median time from injury to MRI was 27 months (range 10–57 months). In 84 (72 %) the original CT from the time of injury was available for review; in the other 32 the radiologist's report was used.

There was no intraparenchymal blood on the initial CT scan (or report) or on the late MRI in 38 cases (33 %), and 78 (67 %) had at least one intraparenchymal haemorrhage on the CT. The total number of individual haemorrhages in these patients was 106. In 69 of these 78 patients, the haemorrhages from the acute stage were all identifiable as such on the MRI. These were nine patients (11.5 %) with at least one haemorrhage which did not show up as haemosiderin on the MRI (total 10 haemorrhages), although seven of these patients had acute parenchymal bleeds in other parts of the brain which were visible on MRI as haemosiderin deposits. The remaining two patients had no visible haemosiderin at all on MRI despite having intracerebral haematomas in the acute phase. Of the ten haematomas with no haemosiderin, nine did show other features to indicate that some "event" had occurred in that part of the brain, such as atrophy, encephalomalacia or a cyst (Fig. 1), although frequently these changes were rather subtle. In

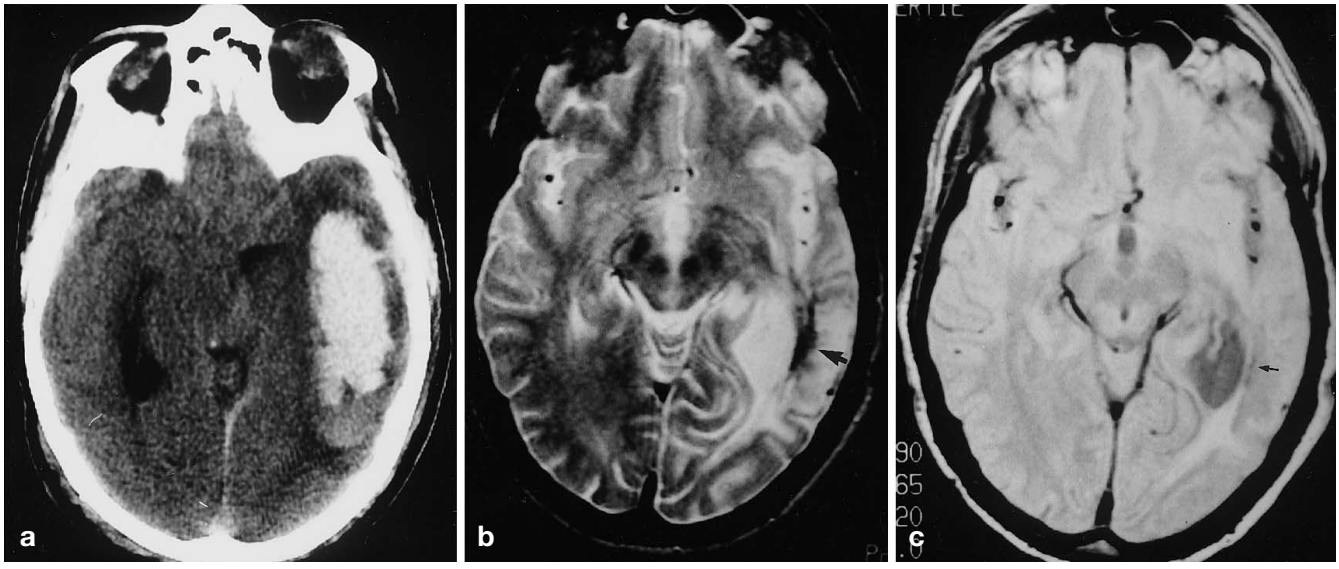

Fig. 2 a–c A well-defined, large, dense, temporal haematoma which "persisted". **a** CT at 6 h; **b, c** T2- and PD-weighted MRI 1 year after injury. Note obvious black haemosiderin in **b** *(arrow),* just visible in **c** *(arrow)*

the patients for whom the early CT was not available for review, there were no haemorrhages mentioned in the original radiologist's report of the early CT which were not visible on the MRI, although it is possible that small haemorrhages not specifically mentioned in the report could have disappeared. There were no significant differences between those with and those without, visible haemosiderin deposition in age, sex, time to initial CT or time to MRI (Table 1). There was no significant relationship between the site or appearance of the haemorrhage on the CT and whether it was visible as haemosiderin deposition on the MRI (Table 2). A larger proportion of haemorrhages which disappeared than of those which persisted had ill-defined edges (90 % vs 71 % respectively, NS), but the number of disappearing haemorrhages (10) was small. A substantial proportion of bleeds invisible on MRI were "large" on the acute CT (Figs. 1, 2).

Table 1 Features of parenchymal brain haemorrhage which remained visible or disappeared on MRI (106 haemorrhages in 78 patients)

	Haemorrhage remained visible	Haemorrhage disappeared
Patients	76	9[a]
Mean age (years)	32	34
Female	16 %	11 %
Mean time (months) from injury to MRI	27.4	27.8

[a] In seven of these at least one other haemorrhage elsewhere in the brain remained visible

Discussion

It would appear that a small proportion (about 10 % of all haematomas but 11.5 % of patients) of traumatic intracerebral haemorrhages do not remain visible as haemosiderin deposition on images obtained with routine spin-echo sequences a year or more after the acute event.

There were no distinguishing features of the haemorrhages that related to whether they did or did not form haemosiderin (or the patients in whom they occurred), and in most patients with a "disappearing" haemorrhage, there was at least one other which did not "disappear". Some "disappearing" haematomas were several centimetres in diameter when acute.

We used routinely available spin-echo sequences on a 1-T imager. In routine practice, gradient-echo T2-weighted sequences, known to be more sensitive to haemosiderin [3], may not be used unless specifically requested or there is a known risk of intracranial haemorrhage. Furthermore, fast spin-echo, increasingly used as "routine" in place of spin-echo T2-weighting is even less sensitive to haemosiderin than spin-echo [4]. Intracerebral haemorrhage following traumatic brain injury may resolve differently from spontaneous PICH, in addition to any differences such as age; however, some of the "disappearing" haemorrhages were radiologically similar to spontaneous ones (Fig. 1).

We have been unable to identify any published imaging studies in which patients known to have an intracerebral haemorrhage were systematically imaged with MRI 3 months or more after the acute event. Al-

Table 2 Relationship of site and appearance of haemorrhage to persistence on late MRI

	Haemorrhage persisted (%)		Haemorrhage disappeared (%)	
Total haemorrhages	96	(100)	10	(100)
Site				
Frontal	39	(41)	2	(20)
Parietal	10	(10)	1	(10)
Temporal	28	(29)	5	(50)
Occipital	3	(3)	0	(0)
Deep hemisphere white matter	4	(4)	0	(0)
Other (basal ganglia, brain stem, cerebellum)	12	(13)	2	(20)
Appearance				
Large	80	(83)	9	(90)
Dense in acute phase	79	(82)	7	(70)
Sharp edge in acute phase	28	(29)	1	(10)

though Scharf et al. [5] recalled 72 patients with PICH for spin-echo imaging, they did not state whether all haematomas remained visible, nor was it clear that review of the images was blinded to the site of the original PICH (their study was undertaken to answer a different question than ours). There are numerous studies documenting the change in appearance on MRI of haemorrhage through acute and subacute to chronic stages [2], but none of these state whether any haemorrhage disappeared and none were systematic studies of a defined population, all imaged late after the event. It is not uncommon to find small areas of haemosiderin in the basal ganglia of elderly people at postmortem examination [6] or on MRI [5, 7] which may have been symptomatic or asymptomatic haemorrhages. However, not all patients who have a cerebral haemorrhage come to postmortem examination (whether they die in the acute phase or years later), so it is impossible to obtain a large patient sample to see whether the pathological features of cerebral haemorrhage always persist indefinitely. One study found that features of cerebral haemorrhage on histology could resolve completely in neonates, but not in a small adult population which was sampled [8]. Patients in whom a problem arises are those with minor strokes (which may be due to small haemorrhages), who are more likely to present late rather than early after stroke, may be on aspirin, and in whom knowledge of the cause of the stroke is vital to guide secondary prevention. In these patients, knowledge that their stroke was due to a haemorrhage, or of a previous asymptomatic intracerebral haemorrhage, would usually preclude use of antithrombotic or anticoagulant drugs because of a potentially increased risk of cerebral haemorrhage [9].

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