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Cognitive bias and clinical reasoning, a case illustration

Dr. Ching Ka Chun

An 86-year-old lady with unremarkable past health was brought to A&E by ambulance for impaired conscious level. The patient was last seen well 3 hours before A&E arrival. She was discovered by family members to be lying on the floor, unresponsive. There was no definite history of trauma and the patient had nil complaints prior to the incident.

The patient was managed in the resuscitation room and her initial vital signs were as follow:

- BP 233/105 mmHg, pulse 92 beats per min
- Oxygen saturation was 96% on room air with respiratory rate 16/min.
- Afebrile
- GCS was E4V1M4

Initial examination showed right eye peri-orbital bruising. Pupils were equal and reactive, with gaze deviation to the left. There was no scalp wound. The patient had spontaneous movement over left upper & lower limbs but no movement was seen on the right side despite repeated stimulation.

Bedside H'stix was 7.3mmol/L. Venous blood gas was unremarkable with normal electrolytes. X-ray of chest and pelvis were unremarkable. Electrocardiogram showed sinus rhythm.

Computed tomography of brain and cervical spine showed acute subdural hematoma (SDH) up to 7mm at right frontal and parietal convexities with no significant mass effect. (Figure 1) The cervical spine was unremarkable.

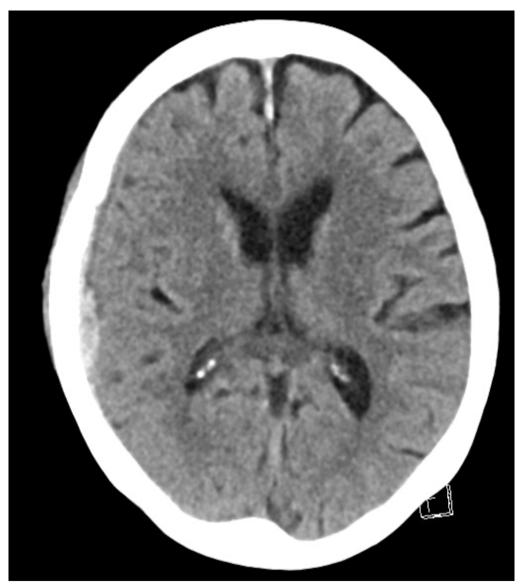

Figure 1: Computed tomography of the brain

Based on the clinical and radiological findings, the preliminary diagnosis was traumatic brain injury (TBI) leading to reduced conscious level.

How to classify the severity of traumatic brain injury (TBI)?

Severity of TBI is traditionally classified according to the Glasgow Coma Scale in which 13-15 = mild injury; 9-12 = moderate injury and <8 = severe TBI.[1]

Common traumatic brain injuries identified in the A&E using plain computed tomography of brain include[2]

- Intraparenchymal haemorrhage
- Traumatic subarachnoid haemorrhage
- Intraventricular haemorrhage
- Subdural haematoma
- Epidural haematoma
- Cerebral contusion
- Diffuse axonal injury

Patients may present with any degree of headache, dizziness, or localizing signs such as one-sided weakness.

Only significant traumatic brain injury that disrupt or lead to occlusion of normal cerebrovascular circulation can produce ischaemia in affected cerebral territories. In general, a minor TBI without significant mass effect is not expected to result in coma or any localizing signs.

Progress of patient

The patient was transferred to a regional hospital for neurosurgical consultation. On reassessment, the receiving physician confirmed the lack of limb movement over the right side with low GCS and wondered whether the minor TBI could explain the clinical findings.

A review of the CT films from the referring hospital showed left dense middle cerebral artery (MCA) sign. (Figure 2)

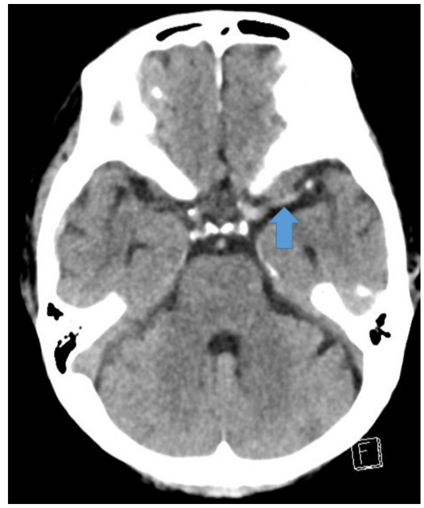

Figure 2: computed tomography of the brain with left dense MCA sign (Blue arrow)

Based on the clinical and CT findings, the diagnosis was revised to primary acute ischemic stroke leading to one sided weakness and depressed conscious level followed by secondary traumatic brain injury.

Stroke call was activated. CT cerebral angiogram (Figure 3) and perfusion scan (Figure 4 and table 1) were arranged and showed left M1 occlusion.

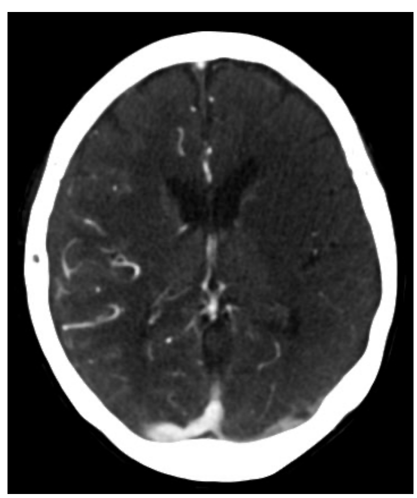

Figure 3: CT cerebral angiogram showed lack of blood flow to the left cerebral hemisphere

What is a CT perfusion scan?

CT perfusion scan requires the administration of intravenous contrast. After bolus of intravenous contrast, a portion of the patient's brain is imaged repeatedly over a short period of time and perfusion maps are generated by post-processing software. It helps to identify the volume of infarcted core tissue and the ischaemic penumbra.

Multiple parameters are assessed with individual map generated. Time to maximum (Tmax) and cerebral blood flow (CBF) are the main parameters used to determine the infarct core and penumbra.

Cerebral blood flow (CBF)

- blood volume flowing through per unit time per unit of brain tissue (ml/100g/min)
- **CBF < 30% volume** indicates the volume of core infarct using the threshold of CBF < 30% of normal.

Time to maximum (Tmax)

- Time from arterial peak to tissue peak after deconvolution
- **Tmax >6s volume** indicates the area of hypoperfusion using the threshold of Tmax greater than 6 seconds

Mismatch volume and mismatch ratio

- Difference in volume between total hypo-perfused area and core infarct
- **Mismatch volume** is the penumbra (volume of hypoperfusion minus volume of core infarct)
- **Mismatch ratio** is the ratio of total hypoperfused area (Tmax < 6s volume) / infarct core volume (CBF <30% volume)

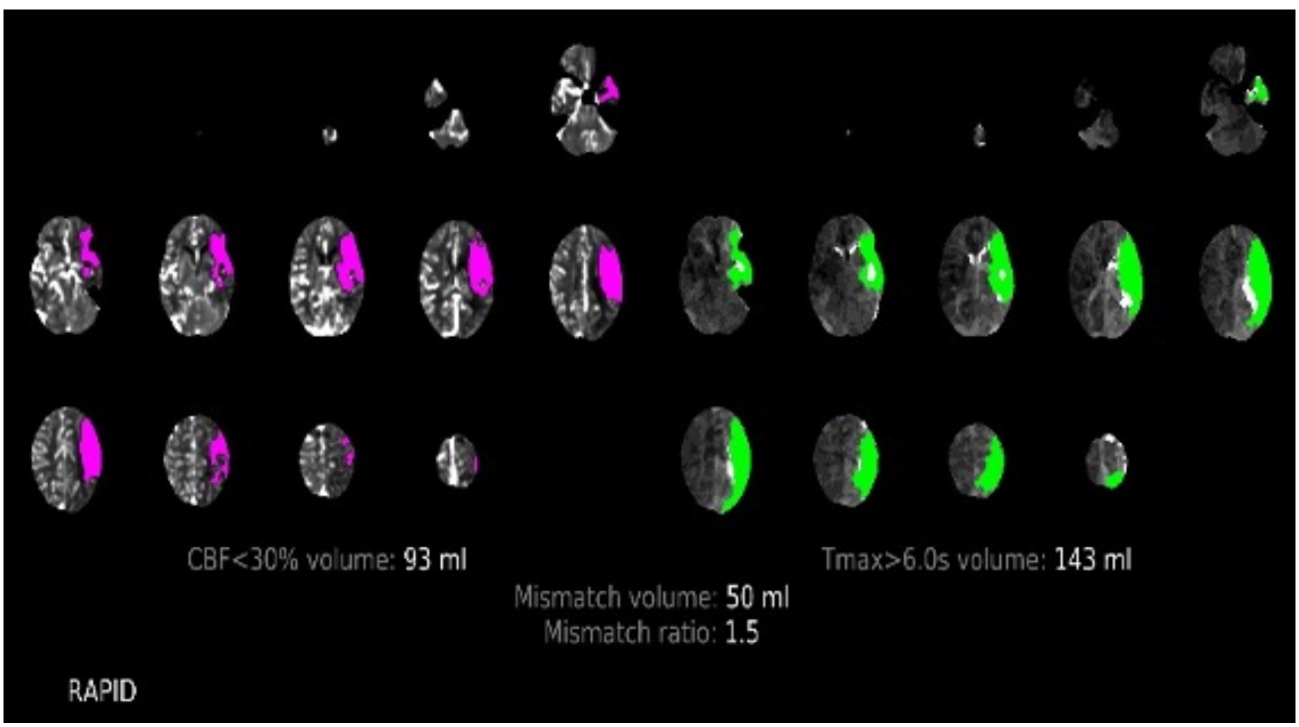

Figure 4: CT Perfusion scan of the patient: Core infarct volume (as indicated by the CBF <30% volume) = 93ml ; Total hypoperfusion volume (as indicated by the Tmax >6.0s volume) = 143ml

Table 1: Parameters measured by the CT perfusion scan of the patient

CBF <30% volume	Core infarct volume (infarcted brain, not salvageable)	93ml
Tmax >6.0s volume	Total hypoperfusion volume	143ml
Mismatch volume	Penumbra (hypoperfused brain at risk of progression to infarct, salvageable)	50ml

What is the precaution in managing this patient?

Acute ischaemic stroke is a neurological emergency. With a narrow therapeutic window for intervention, a prompt recognition is critical. The first-line emergency treatment is thrombolytic therapy with intravenous recombinant tissue-type plasminogen activator. It must be administered within 3 to 4.5 hours after onset of symptoms for optimal efficacy.[3,4]

However, intravenous thrombolysis is contra-indicated in patients with any type of acute intra-cranial haemorrhage (Intracerebral, subarachnoid, subdural). Therefore, intravenous thrombolysis should not be given to our patient.

Another concern for our patient is the large core infarct volume which is often defined as an ASPECTS <6 in non-contrast CT scan or an ischaemic core volume greater than 50-70ml in CT perfusion scan.

Although the efficacy of mechanical thrombectomy for ischemic stroke due to anterior circulation large vessel occlusion has been established, the benefit of it in those patients with large infarct core is not.

Traditionally, it has been thought that patients with a large-core infarct would be unlikely to benefit from thrombectomy because the damage to the brain has already been done.

Large core infarct volume is a common exclusion criterion for mechanical thrombectomy in patients with large vessel occlusion stroke due to the uncertain benefit and higher risk of haemorrhagic transformation.[5,6]

However, a recent randomized clinical trial involving 203 patients with acute ischaemic stroke with large core infarct volume showed better functional outcomes with mechanical thrombectomy than with medical care alone but had more intra-cranial haemorrhage.[7]

Although evidence from further studies were pending, acute stroke patients with a large ischaemic core may still benefit from mechanical thrombectomy.[8-13]

Progress of patient

The patient directly underwent mechanical thrombectomy without intravenous thrombolysis and achieved a final modified Thrombolysis in Cerebral Infarction Score (mTICI score) of 2b.

What is mTICI score?

The modified Thrombolysis in Cerebral Infarction score (mTICI score) is used to assess cerebral perfusion before and after mechanical thrombectomy. (Table 2) Successful reperfusion is usually defined as a mTICI score of 2B or 3 at the end of the procedure.[8]

Table 2: mTICI score

Score	Description
0	No perfusion
1	Perfusion past initial obstruction but limited distal branch filling with little/slow distal perfusion
2a	Partial reperfusion: <50% of major vascular territory perfused
2b	Partial reperfusion: >/=50% of major vascular territory is filled, but there is not complete and normal perfusion of entire territory
3	Complete or full perfusion with filling of all distal branches

Progress of patient

The patient was admitted to the ICU for further observation. Unfortunately, patient had poor neurological recovery and was complicated by hemorrhagic transformation of the established infarct. Neurosurgery was consulted and surgical treatment was not advisable. The patient finally succumbed despite best medical treatment.

Why was the diagnosis of the patient revised after transfer?

This case serves to illustrate the not uncommon pitfalls in clinical reasoning that affect both new and even seasoned physicians.

Provided there is no immediate need to address airway, breathing and circulation issues, we always start our assessment with history taking, physical examination and relevant investigations before arriving at our diagnosis and its differentials.

Throughout this information gathering phase, we need to constantly evaluate the relevance and importance of each clinical evidence and prioritize them accordingly. Finally, this constellation of findings may favor one diagnosis over the others.

Although this patient's peri-orbital bruising and SDH readily suggests a traumatic cause, an astute physician should realize the minor TBI was unable to explain this profound neurological deficit. He/She would then need to go through the evidence again, in search for a more likely explanation that better fits the clinical picture.

Since the receiving physician suspected a missing pathology in the CT brain, he/she diligently reviewed the films again to discover the hidden, and the much less obvious dense left MCA sign.

Having this piece of information allows a more plausible story to be constructed: the patient was most likely to have suffered a dense left MCA stroke leading to impaired sensorium and right-side weakness which contributed to her fall with head injury and a small SDH.

Cognitive bias in clinical reasoning and way to avoid them

Physicians, though highly learned, are not immune to making errors. We often use cognitive short cuts to aid our decision making; however, these cognitive shortcuts are often cognitive biases as well. It is apparent that many diagnostic errors stem from cognitive bias,[14] and has nothing to do with individual physician's intelligence or lack of cognitive ability.[15] It is estimated that diagnostic errors in the emergency department occur 5-10% of the time.[16]

Physicians strive to arrive at the correct diagnosis but many times it is not as straightforward. We may find ourselves anchoring at a diagnosis without searching for other alternatives, dismissing evidence that speaks against our diagnosis or pre-maturely stopping to seek for additional information to approve/disprove our conclusion.

Up to 75% of errors in internal medicine are cognitive in origin (from diagnostic process, information gathering, association triggering to processing and verification).[17] Although there is growing recognition of cognitive error, this field of research is challenging to conduct due to lack of high-quality data of prevalence and difficulty in studying a clinician's thought process. Despite these challenges, current literature has identified and categorized some of the more common biases which are listed in the table below.[18] (Table 3)

Methods have been suggested to reduce cognitive bias, e.g bias specific teaching sessions, deliberately slowing down our thought process, meta-cognition & thinking of alternatives and developing checklists etc.[18]

However, until cognitive bias is more widely recognized and included in our medical curriculum, we have only our constant awareness to rely on.

Next time when we face a diagnostic dilemma, we may challenge ourselves cognitively with the following three simple questions:

1. Is it what I think it is? (Gather and summarize available evidence from history, physical and investigation results)
2. Can it be something else? (Challenge your diagnosis with other hypotheses)
3. What deadly diagnosis must I not miss?

These questions can help expand the differential diagnosis to include things that may have been left out because of cognitive errors and thus trigger clinicians to obtain further necessary information.

Table 3: Common biases

	Definition	Example
Availability bias	Recent and readily available answers are favored because of ease of recall	A recently missed aortic dissection will prompt the clinician to think of it in all patients presenting with chest pain.
Confirmation bias	Interpret information to fit the pre-conceived diagnosis	A patient with dark urine must be due to hematuria because the urine dipsticks is "Large" for RBC, neglecting it may in fact be myoglobinuria.
Over-confidence	Presumed excellence in diagnostic ability leading to errors	
Search satisfying	Ceasing to look for further information when the first plausible solution is sought	An obvious SDH overshadows the more subtle dense MCA
Representativeness	Mis-judging the likelihood of an event based on similar findings shared among common and rarer disease	

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