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Introduction

Intracranial aneurysm is the leading cause of nontraumatic subarachnoid haemorrhage (SAH) which is a neurological emergency. Aneurysmal SAH (aSAH) is associated with as much as 67% patient fatality and 10 to 20% long term dependence in survivors, with substantial burden on healthcare resources, mainly due to hospitalisation. Misdiagnosis accounts for 50% in patients presenting their first visit in the absence of classic SAH signs and symptoms. Neurologic complications such as symptomatic vasospasm, hydrocephalus and rebleeding are common. Vasospasm represents the leading cause of death and disability with 50% of patients will eventually develop ischaemic stroke. Early recognition and prompt treatment of vasospasm can improve neurologic outcome. Digital-subtraction cerebral angiography (DSA) was the gold standard for the detection of cerebral aneurysm and vasospasm in SAH patients. However, this procedure is invasive, expensive, not always available and has limited ability to quantify cerebral blood flow or the risk of cerebral ischaemia. Transcranial Doppler (TCD) has been implemented by many neurosurgical units due to its non-invasiveness in detecting cerebral vasospasm. Similarly, cerebral Computed Tomography perfusion (CTP) which assesses brain perfusion haemodynamics in these cases is non-invasive. Measurement of brain perfusion has been said to be clinically useful for identifying SAH patient at risk of cerebral ischaemia, guiding further therapeutic decision and monitoring treatment effect. However, the effectiveness and safety of TCD and cerebral CTP in the management of aSAH remained debatable. This review was requested by the Director of Sungai Buloh Hospital, Ministry of Health Malaysia to review the evidence on TCD and cerebral CTP to be used in the management of aSAH.

Objective/Aim

To assess the effectiveness and safety of TCD and cerebral CTP as a non-invasive diagnostic procedure in the management of aSAH.

Results and Conclusions

Transcranial Doppler (TCD) Ultrasound

There was limited retrievable fair level of evidences from the electronic databases on the effectiveness and safety of TCD in the management of aneurysmal SAH whereby four full text articles were included in this systematic review; namely systematic review of comparative trials (1), comparative trial (1) and cross sectional (2) in design.

Evidence demonstrated that TCD appeared beneficial for the detection and monitoring of angiographic vasospasm of the intracranial arteries due to ruptured aneurysms, especially the middle cerebral artery. TCD demonstrated good diagnostic value in the detection of cerebral vasospasm after aneurysmal haemorrhage for middle cerebral arteries with high positive likelihood ratio (17) and high specificity, however its diagnostic value for ACA was low (positive likelihood ratio <5). The sensitivity in detecting MCA vasospasm varies from 64% to 67% with specificity from 78% to 99%; in ACA vasospasm the sensitivity ranges from 42% to 45% with specificity of 76% to 84%; while in ICA vasospasm the sensitivity was between 25% to 80% with specificity ranges from 77% to 91%. Evidence also showed that these TCD parameters; middle cerebral artery velocity (VMCA) measurements and V_{MCA}/V_{ICA} ratio can increase the accuracy of TCD. This investigational procedure also appeared safe with CE certification and without reported adverse event.

This is in tandem with the Guideline from the American Heart/Stroke Association on the Management of Aneurysmal Subarachnoid Haemorrhage which stated that TCD is reasonable to monitor the development of arterial vasospasm after aneurysmal SAH. Similarly, TCD is stated as useful for the detection and monitoring of angiographic vasospasm in the basal segments of the intracranial arteries, especially the middle cerebral artery and basilar artery after aSAH as documented by the American Academy of Neurology in its assessment.

Computed Tomography Perfusion (CTP)

There was limited retrievable fair level of evidence from the electronic databases on the effectiveness and safety of CTP in the management of aneurysmal SAH, with three full text articles (all cross sectional in design) included in this systematic review specifically in the detection of

cerebral vasospasm and secondary cerebral infarction after aneurysmal SAH.

Evidences demonstrated that CTP appeared useful in the detection of vasospasm in suspected patients after aSAH. For the diagnosis of angiographic vasospasm, diagnostic performance of CTP as measured by mean transit time (MTT) with a threshold of 6.4 seconds was the most sensitive parameter.

Evidences also showed that CTP appeared useful in the detection of secondary cerebral infarction after aneurysmal SAH, with CTP derived parameter, time-to-peak was the most sensitive parameter.

Evidence also has demonstrated that CTP seemed beneficial in providing immediately applicable information for diagnosing vasospasm, which could further guide decisions for endovascular treatment in the management of aSAH. In term of CTP use to assist decision for endovascular treatment of angiographic vasospasm, evidence showed that the most accurate CTP parameter was cortical regional cerebral blood flow value (rCBF)(94.8%), with sensitivity and specificity of 61.7% and 98.2% respectively. This procedure appeared safe with no safety issue raised related to its use.

This is in line with the Guideline on the Management of Aneurysmal Subarachnoid Haemorrhage by the American Heart/Stroke Association which documented that perfusion imaging with computed tomography or magnetic resonance can be useful in identifying region of potential brain ischaemia after aneurysmal SAH.

Methods

Literature were searched through electronic databases which included PubMed, Medline, Cochrane Database of Systematic Reviews, Cochrane Database of Controlled Trial, Health Technology Assessment, National Horizon Scanning, other websites; INAHTA, ASERNIP-S, CADTH, FDA, MHRA and general databases such as Google. Additional articles retrieved from reviewing the bibliographies of retrieved articles or contacting the authors. A critical appraisal of all relevant literature was performed using Critical Appraisal Skills Programme (CASP) checklist, diagnostic accuracy evidence were graded according to the NHS Centre for Reviews and Dissemination (CRD) University of York, Report Number 4 (2nd Edition) for diagnostic accuracy studies (Appendix 2a) while effectiveness evidence were graded according to the US/Canadian Preventive Services Task Force Level of Evidence (2001).