Clinical Neurology and Neurosurgery 155 (2017) 83–89

Contents lists available at ScienceDirect

Clinical Neurology and Neurosurgery

journal homepage: www.elsevier.com/locate/clineuro

Blood transfusion indications in neurosurgical patients: A systematic review

Shefali Bagwe[a], Lawrance K. Chung[a], Carlito Lagman[a], Brittany L. Voth[a], Natalie E. Barnette[a], Lekaa Elhajjmoussa[a], Isaac Yang[a,b,c,d,*]

[a] Departments of Neurosurgery, University of California, Los Angeles, United States
[b] Radiation Oncology, University of California, Los Angeles, United States
[c] Head and Neck Surgery, University of California, Los Angeles, United States
[d] Jonsson Comprehensive Cancer Center, University of California, Los Angeles, United States

ARTICLE INFO

Article history:
Received 20 January 2017
Received in revised form 7 February 2017
Accepted 12 February 2017
Available online 20 February 2017

Keywords:
Blood transfusion
Cerebral neoplasm
Intracranial aneurysm
Neurosurgery
Subarachnoid hemorrhage
Traumatic brain injury

ABSTRACT

Neurosurgical procedures can be complicated by significant blood losses that have the potential to decrease tissue perfusion to critical brain tissue. Red blood cell transfusion is used in a variety of capacities both inside, and outside, of the operating room to prevent untoward neurologic damage. However, evidence-based guidelines concerning thresholds and indications for transfusion in neurosurgery remain limited. Consequently, transfusion practices in neurosurgical patients are highly variable and based on institutional experiences. Recently, a paradigm shift has occurred in neurocritical intensive care units, whereby restrictive transfusion is increasingly favored over liberal transfusion but the ideal strategy remains in clinical equipoise. The authors of this study perform a systematic review of the literature with the objective of capturing the changing landscape of blood transfusion indications in neurosurgical patients.

Contents

* Corresponding author at: Department of Neurosurgery, University of California, 300 Stein Plaza, Suite 562, 5th Floor Wasserman Building, Los Angeles, California 90095-6901, United States.
E-mail address: iyang@mednet.ucla.edu (I. Yang).

http://dx.doi.org/10.1016/j.clineuro.2017.02.006
0303-8467/

1. Introduction

Neurosurgical procedures can be complicated by significant blood losses requiring red blood cell transfusions (RBCTs). However, the precise level or extent of anemia that is clinically relevant is unclear, as the effect of low tissue perfusion and oxygenation is likely tissue dependent and can vary between patients [1]. Decreased tissue perfusion becomes particularly important in neurosurgical patients due to the possibility of secondary cerebral injury. Still, controversy exists regarding thresholds for transfusion and what types of transfusions are most meaningful in these patients. Evidence-based guidelines concerning blood transfusion in neurosurgery are also relatively scarce. Thus, transfusion medicine within neurosurgical practices are highly variable and often based on institutional preferences. The authors of this study perform a systematic review of the literature with the objective of capturing the changing landscape of blood transfusion practices in neurosurgical patients, specifically those undergoing surgery for intracranial aneurysms, management of subarachnoid hemorrhage (SAH), treatment of traumatic brain injury (TBI), and resection of brain tumors.

Anemia is defined by the World Health Organization (WHO) as a hemoglobin (Hb) level of less than 12 g/dL in women and less than 13 g/dL in men [2]. Some reports suggest that a Hb level of 7–9 g/dL will not cause secondary neuronal injury, but the exact value at which anemia is harmful in neurosurgical patients is unknown [3,4]. Currently, RBCT is the quickest and most effective way to raise Hb concentration [5]. Blood transfusions typically fall into 2 general categories, with advantages and disadvantages inherent to each:

1. Allogeneic blood transfusions require constant availability of blood donors, as well as facilities for blood grouping, cross matching, storage, and transportation; such requirements, make allogeneic transfusions expensive. In addition, transmission of viral diseases such as HIV and Hepatitis-B are associated risks of allogeneic transfusions.
2. Autologous blood transfusions involve the donation of red blood cells (RBCs) by the patient, transfusion of the blood products, and hemodilution. Preoperative autologous donation results in iatrogenic anemia and an increased frequency of RBCT [6]. However, autologous RBCT is more cost-effective than allogeneic RBCT [7].

Oxidative metabolism is the primary means of energy production in the brain. Thus, maintenance of cerebral perfusion pressure is critical for brain function and health. Major factors involved in ischemic brain injury include increased intracellular cytosolic calcium concentration, metabolic acidosis, and production of free radicals [8]. Increased accumulation of excitatory amino acids such as glutamate and aspartate, during ischemia, also contribute to selective neuronal death. In feline experiments, Shimada et al. demonstrated that decreasing cerebral blood flow (CBF) to 20 ml/100 g/min from a baseline CBF of 55 ± 3.3 ml/100 g/min in a control group, led to increased extracellular glutamate release and accumulation, possibly because of impaired uptake of glutamate due to deficient adenosine triphosphate supplies [9].

Increased extracellular glutamate is associated with large calcium influxes coupled with impaired intracellular calcium sequestration mechanisms. The rise in intracellular calcium activates a series of catabolic enzymes that ultimately lead to neuronal death. Hence, the basic principle in neurocritical care is to avoid secondary injury of the already compromised brain parenchyma by ensuring adequate oxygenation. Secondary injury to the brain has been shown to occur at a hematocrit (HCT) of 20% or less, which is approximately equivalent to a Hb concentration of 6–7 g/dL [8]. Hb carries the vast majority of total oxygen (O_2) content dissolved in the blood and a reduction in Hb concentration (i.e., anemia) can dramatically reduce O_2-carrying capacity. Impaired O_2 delivery to the vital, highly-metabolic brain can lead to irrevocable damage. Thus, it is imperative that Hb levels be maintained especially in the setting of acute blood loss.

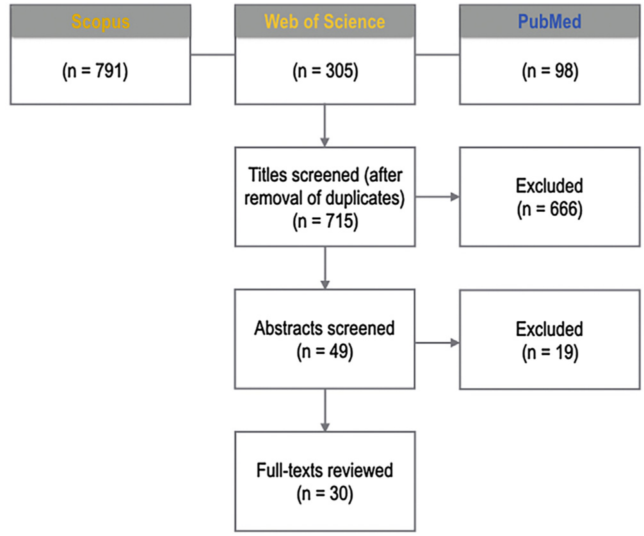

Fig. 1. Search strategy.

2. Methods

This systematic review was prepared according to the Preferred Reporting Items for Systematic Review and Meta-analysis (PRISMA) standard.

2.1. Sources and search strategy

The Scopus, Web of Science, and PubMed databases were searched by independent authors (LC and CL) through February 7, 2017. Seven strategic search term combinations were used (Table 1). The search strategy is summarized Fig. 1. English, full-text randomized controlled trials, prospective cohorts, and retrospective clinical studies were selected. Titles and abstracts were screened, and relevant full-text articles were reviewed. Bibliographies of the full-texts were surveyed for additional pertinent studies.

2.2. Study selection

Studies investigating transfusion of packed red blood cell (pRBC) products [10–32], including autologous [6,7], allogeneic [7,33], and salvage RBCs [34,35], in neurosurgical patients undergoing intracranial surgery and medical management, were included. The primary areas of interest were general neurosurgical practice, subarachnoid hemorrhage (SAH), traumatic brain injury (TBI), and brain tumor surgery. Studies investigating transfusion of RBC products in the context of craniosynostosis or spine surgery were excluded. Transfusions of prothrombin complex concentrate, fresh frozen plasma, platelets, or other non-RBC products were considered irrelevant and studies describing their use were excluded. The main findings of each study are summarized in Table 2.

3. General practices

In a normal brain, when Hb concentration falls to <10 g/dL, compensatory vasodilation occurs to ensure adequate blood supply [36]. Compensatory vasodilation maintains adequate perfusion