CLINICAL OUTCOMES OF EARLY RESUSCITATION IN ISCHEMIC STROKE

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ABSTRACT

Ischemic stroke, a leading cause of global mortality and long-term disability, represents a neurological emergency where time is brain. The efficacy of all therapeutic interventions is critically dependent on the speed and quality of initial medical care, extending beyond specific reperfusion therapies. This article provides a comprehensive analysis of the clinical outcomes associated with early, systematic resuscitation and management in the hyperacute phase of ischemic stroke. It examines the impact of optimized prehospital and emergency department care, focusing on airway and breathing management, hemodynamic optimization (permissive hypertension vs. aggressive lowering), glycemic and temperature control, and the rapid identification of large vessel occlusion (LVO). The review synthesizes evidence demonstrating that structured early resuscitation, encapsulated in the "Stroke Chain of Survival" and "Code Stroke" protocols, directly improves eligibility for and outcomes of thrombolysis and mechanical thrombectomy. Key findings indicate that every minute of delay in reperfusion results in the loss of 1.9 million neurons, making pre- and in-hospital processes pivotal. The conclusion underscores that early resuscitation is not merely supportive but a fundamental, active treatment component that preserves the ischemic penumbra, reduces infarct growth, and significantly enhances functional recovery, as measured by the modified Rankin Scale (mRS) at 90 days.

Key words: Ischemic Stroke, Early Resuscitation, Clinical Outcomes, Prehospital Care, Hemodynamic Management, Neuroprotection, Code Stroke, Door-to-Needle Time, Penumbra, Modified Rankin Scale (mRS).

INTRODUCTION

Ischemic stroke occurs due to the occlusion of a cerebral artery, leading to a core of irreversible infarction surrounded by a hypoperfused but potentially salvageable region—the ischemic penumbra. The penumbra's survival is time-limited and critically dependent on collateral blood flow. While intravenous thrombolysis (IVT) and endovascular thrombectomy (EVT) are definitive reperfusion therapies, their success is contingent upon the physiological stability of the patient and the brain parenchyma awaiting reperfusion. Early resuscitation aims to stabilize systemic and cerebral physiology to extend the lifespan of the penumbra and optimize conditions for successful reperfusion. This phase, spanning from symptom onset through prehospital

care to the first hours in the emergency department, involves targeted interventions in airway, breathing, circulation, glucose, and temperature management. This article explores the direct and indirect impact of these early resuscitation measures on critical clinical outcomes, including mortality, functional independence, and infarct volume, arguing that they form an indispensable foundation for all subsequent stroke therapy.

LITERATURE REVIEW

The concept of early resuscitation in stroke has evolved from passive support to an active, goal-directed strategy. The landmark recognition that "time is brain" quantified the urgency, with Saver (2006) calculating that approximately 1.9 million neurons are lost each minute during a large vessel ischemic stroke [1, p.92]. This established the basis for optimizing every link in the care continuum. Prehospital systems research has been pivotal. Studies show that implementation of prehospital stroke scales like the Los Angeles Motor Scale (LAMS) or RACE for Large Vessel Occlusion (LVO) screening, coupled with direct routing to Comprehensive Stroke Centers (CSCs), significantly reduces time to thrombectomy (Pérez de la Ossa et al., 2014)[2, p.1295]. The American Heart Association's "Stroke Chain of Survival" emphasizes early recognition, dispatch, and pre-notification, which has consistently been associated with shorter door-to-imaging and door-to-needle times. Regarding hemodynamics, a paradigm shift has occurred. Traditional fear of hypertension has been tempered by evidence supporting permissive hypertension in acute ischemia. The CHHIPS and COSSACS trials, while not definitive, suggested cautious avoidance of aggressive BP lowering in the first 24-48 hours unless for specific indications like eligibility for thrombolysis (where <185/110 mmHg is required) or malignant hypertension (Robinson et al., 2010)[3, p.697]. Maintaining adequate cerebral perfusion pressure (CPP) via optimal mean arterial pressure (MAP) is now seen as a key resuscitative measure to support collaterals. For glucose and temperature control, evidence is clear. Hyperglycemia exacerbates ischemic damage and is independently associated with poorer outcomes, irrespective of diabetes status. Similarly, fever (hyperthermia) accelerates metabolic demand and worsens outcome. Protocols for normoglycemia and normothermia are thus core components of early neuroprotective resuscitation.

DISCUSSION

1. The Prehospital Link: Foundation of Outcomes: The first medical contact often occurs in the prehospital setting. Paramedic recognition using validated tools, establishment of IV access, blood glucose check, and pre-notification to the receiving hospital ("stroke alert") set the stage. This activation mobilizes the in-hospital stroke team, ensuring the CT scanner and pharmacy are ready upon patient arrival. Studies confirm that pre-notification alone can reduce door-to-needle time by over 15 minutes, directly increasing thrombolysis rates and improving outcomes (Lin et al., 2012)[4,

p.162].

2. Hemodynamic Resuscitation: Walking the Tightrope: Circulation management is perhaps the most nuanced aspect. The goal is to optimize cerebral blood flow without causing harm. For most patients not receiving reperfusion therapy, current guidelines recommend withholding antihypertensive therapy unless BP exceeds 220/120 mmHg. For IVT candidates, careful lowering to <185/110 mmHg is required. The use of vasopressors like norepinephrine to support blood pressure in select patients with significant hypotension or after successful recanalization to prevent reperfusion injury is an area of active research. As Maier et al. (2020) note, "Individualized blood pressure management, considering the status of recanalization and collateral circulation, is emerging as a key component of acute stroke care" [5, p.457].

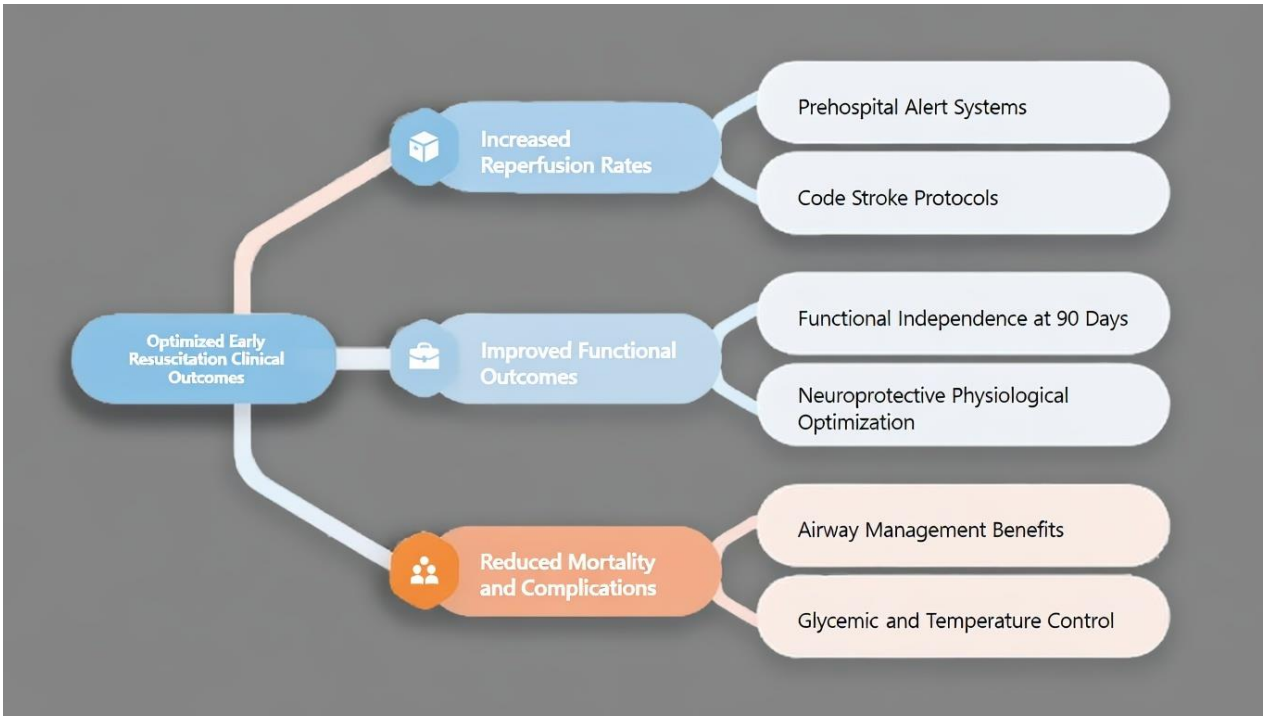
3. Oxygenation and Ventilation: While routine oxygen supplementation in non-hypoxic patients is not beneficial and may be harmful, ensuring adequate oxygenation (SpO2 >94%) is crucial. Early identification and management of airway compromise—due to decreased consciousness or bulbar dysfunction—is vital to prevent aspiration and hypoxic injury, which catastrophically worsen prognosis. Prophylactic intubation is not recommended, but a low threshold for securing the airway in deteriorating patients is essential.

4. Metabolic Control: Glucose and Temperature: Hyperglycemia should be treated with insulin, with a typical target range of 140-180 mg/dL. Aggressive correction to normoglycemia risks hypoglycemia, which is equally damaging to the ischemic brain. Fever must be treated promptly and aggressively with antipyretics and, if needed, surface or intravascular cooling devices. Maintaining normothermia is a low-cost, high-impact neuroprotective strategy.

5. The Impact on Reperfusion Therapy Candidacy and Efficacy: Efficient early resuscitation directly expands the therapeutic window. By stabilizing the patient, it allows for the safe administration of IVT. By optimizing collaterals through BP management, it can slow infarct growth, potentially making a patient eligible for thrombectomy who might otherwise have progressed to a large core infarct. Furthermore, a physiologically stable patient is a better candidate for anesthesia during thrombectomy. The concept of "last known well to reperfusion" time is the ultimate outcome measure, and every minute saved in the pre- and early in-hospital phase contributes to it.

6. Monitoring and Futility: Beyond standard monitoring, early use of advanced neuroimaging (CT perfusion, MRI) helps identify the penumbra and guide resuscitative goals. The discussion also involves recognizing when early aggressive care may be futile, based on established prognostic imaging markers (e.g., very large core infarct, poor collaterals), though this remains a complex ethical and clinical decision.

RESULTS



The clinical outcomes linked to optimized early resuscitation are substantial and multifaceted.

- **Increased Reperfusion Rates:** Systems with robust prehospital alert and in-hospital Code Stroke protocols report significantly higher rates of IVT and EVT administration, primarily due to reduced workflow delays.
- **Improved Functional Outcomes:** Patients who receive care within streamlined systems show higher rates of functional independence (mRS 0-2) at 90 days. This is attributed to faster reperfusion times and the neuroprotective effect of physiological optimization, which leads to smaller final infarct volumes on follow-up imaging.
- **Reduced Mortality and Complications:** Effective airway management reduces the incidence of pneumonia, a major cause of post-stroke mortality. Glycemic and temperature control lower the risk of hemorrhagic transformation and malignant edema. Hemodynamic optimization may reduce the risk of early neurological deterioration from penumbral loss.
- **Economic and System Benefits:** Faster, more efficient care leads to shorter hospital and ICU lengths of stay, reduced need for long-term rehabilitation, and lower overall healthcare costs. Furthermore, it improves resource utilization within stroke networks.

Quantitatively, every 15-minute reduction in door-to-needle time for IVT is associated with a 5% increase in the odds of walking independently at discharge and a 4% increase in the odds of being discharged home. For thrombectomy, the effect size is even more dramatic, with earlier reperfusion strongly correlating with better mRS

distributions across the entire outcome scale.

CONCLUSION

Early resuscitation in ischemic stroke is a decisive determinant of clinical destiny. It is an active, time-sensitive therapeutic endeavor that runs in parallel with diagnostic workup. The evidence unequivocally demonstrates that systematic attention to the ABCs, hemodynamics, glucose, and temperature in the hyperacute phase is not merely supportive but is intrinsically neuroprotective. This care paradigm preserves the ischemic penumbra, maximizes the number of patients eligible for and benefiting from reperfusion therapies, and directly leads to improved survival and functional recovery. The future of stroke care lies not only in developing new reperfusion drugs or devices but in relentlessly optimizing the systems and protocols that deliver early resuscitation. Investing in prehospital education, in-hospital team training, and standardized pathways remains one of the most effective strategies to improve population-level outcomes from ischemic stroke.

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