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Optimal Transport System for Acute Ischemic Stroke Patients: A Cost-Effectiveness Analysis

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Abstract. This study conducted cost utility analysis comparing 4 systems of transporting acute ischemic stroke patients in Hokkaido, Japan. Hypothetical patients were generated on a geographic information system, and their outcomes were estimated according to their transport time to hospitals administering tissue plasminogen activator and/or endovascular thrombectomy. The transport systems where a neurointerventionist traveled for earlier endovascular thrombectomy were most cost-effective in some rural areas, while direct transportation to comprehensive stroke centers was more cost-effective in other areas.

Keywords. Acute ischemic stroke, Cost-effectiveness, Transport system

1. Introduction

While treatments for acute ischemic stroke (AIS) patients are time-urgent, there is regional disparity in the administration and provision rates of tissue plasminogen activator (t-PA) and endovascular thrombectomy (EVT)—the most effective treatments—partly because of inequalities in the distribution of medical resources such as hospitals and more importantly, qualified neurointerventionists for EVT.

Several systems to transport such patients exist and have been studied. Some studies have compared the "mothership," where patients are directly transported to comprehensive stroke centers administering t-PA and EVT (Hubs), with "drip and ship," where patients are transported to nearby hospitals for t-PA before being transported to a Hub [1]. In addition, the benefit and cost-effectiveness of the "drive and retrieve" system, where a neurointerventionist travels to another hospital (Spoke) for earlier EVT, have been analyzed [2,3]. However, no study has compared the transport systems both from outcomes and cost-effectiveness perspectives, even though such an analysis is of great importance when considering the implementation of these systems as healthcare policy. Optimal transport system could differ in each area depending on factors such as resource distributions.

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2. Methods

The subjects were 21 medical areas in Hokkaido, Japan. In the cost utility analysis, 4 transport systems for AIS patients (mothership, drip and ship, drive and retrieve, and drip and drive, where a neurointerventionist travels to a Spoke for earlier EVT and patients are transported to a Spoke after being treated with t-PA) were compared.

The primary outcome was the incremental cost-effectiveness ratio (ICER). The ICER was evaluated using the value of 5 million yen ($US34,109)/quality-adjusted life year (QALY), one of the thresholds in Japanese Cost-effectiveness Evaluation. The analysis was from the local government's perspective and the costs included were medical, long-term care, and system implementation costs. It was assumed that a neurointerventionist was hired by the local government for drive and retrieve and drip and drive.

Hypothetical 1,445 patients were generated according to the demographics and population randomly across Hokkaido using "create random point" function of ArcGIS Pro (Esri). Then, their transport time was analyzed using ArcGIS. Since patient severity is time dependent, severity at three months was estimated based on the transport time.

Patient severity between the 4^{th} and 120^{th} months was estimated using Markov modeling with 3 health states: physically independent, severe, and death. Transition probability was estimated based on previous studies and the Japanese life table. Costs and utility were defined for each health state, estimated from extant literature.

3. Results

The mothership transporting system was more cost-effective than drip and ship in most of the areas. Compared to the mothership, drive and retrieve and drip and drive were more effective in rural areas such as Hokumo and Soya, with ICERs $US6,487/QALY and $US2,312/QALY for Hokumo and $US 6,735/QALY and $US 16,612/QALY for Soya, respectively. Conversely, in most of the areas, the ICERs for drive and retrieve and drip and drive were more than JPY5 million/QALY compared to the mothership.

4. Conclusions

Drive and retrieve and drip and drive systems, where a neurointerventionist traveled to a Spoke, improved patient outcomes and were cost-effective especially in rural areas such as Hokumo and Soya, even when considering the cost of hiring a neurointerventionist. Conversely, the mothership was most cost effective in most of the other areas.

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