Mobile Extracorporeal Membrane Oxygenation Teams: The North American Versus the European Experience

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Objective: **To evaluate differences in the inclusion of anesthesiologists in mobile extracorporeal membrane oxygenation (ECMO) teams between North American and European centers.**

Design: **A retrospective review of North American versus European mobile ECMO teams. The search terms used to identify relevant articles were the following: "extracorporeal membrane transport," "mobile ECMO," and "interhospital transport."**

Setting: **MEDLINE review of articles.**

Participants: **None.**

Interventions: **None.**

Results: **Between 1986 and 2015, 25 articles were published that reported the personnel makeup of mobile ECMO teams in North America and Europe: 6 from North American centers and 19 from European centers. The included articles reported a total of 1,329 cases: 389 (29%) adult-only cohorts and 940 (71%) mixed-age cohorts. Among North American studies, 0 of 6 (0%) reported the presence of an anesthesiologist on the mobile ECMO team in contrast to European studies, in which 10 of 19 (53%) reported the inclusion of an anesthesiologist (Fisher exact p for difference = 0.05). In terms of number of cases, this discrepancy translated to 543 total cases in North America (all without an anesthesiologist) and 499 cases in Europe (37%) including an anesthesiologist on the team (Fisher exact p for difference <0.001).**

Conclusions: **This study demonstrated significant geographic discrepancies in the inclusion of anesthesiologists on mobile ECMO teams, with European centers more likely to incorporate an anesthesiologist into the mobile ECMO process compared with North American centers.**

KEY WORDS: extracorporeal membrane oxygenation, anesthesiology, mobile ECMO

EXTRACORPOREAL MEMBRANE OXYGENATION (ECMO) is a potentially lifesaving modality used in critically ill patients who experience severe cardiac and/or pulmonary failure, and its use has increased over the past 2 decades.[1,2] Along with the rise in ECMO utilization, the ability to provide interhospital transfer to tertiary care centers with the assistance of ECMO support has led to the emergence of critical questions regarding the appropriate timing and execution of such transfers. Transport ECMO was first reported by Cornish et al in 1986,[3] but standardization of this complex undertaking remains a potentially important quality improvement opportunity worthy of investigation.

Despite a relative paucity of data regarding transport ECMO, increasing numbers of primary and secondary care facilities are using mobile ECMO for interhospital transfer of critically ill patients to tertiary care centers.[4] Appropriately equipped hospitals and other healthcare facilities around the world have put ECMO teams in place to carry out these transfers, but the makeup of these teams is not standardized across centers. Thus far, the largest systematic review of the mobile ECMO literature did not focus on the makeup of these teams across institutions or geographic regions.[5]

Accordingly, for this study, the authors analyzed differences in the personnel used during transport ECMO, with a particular focus on the inclusion of anesthesiologists in mobile ECMO teams as it differs between North American and European centers. Secondarily, the authors sought to perform a qualitative review of the complications encountered during the mobile ECMO experience between North American and European centers.

METHODS

Search Criteria

The authors conducted a PubMed database search to identify literature that reported experiences with interhospital transfer of patients undergoing ECMO. The search terms used for identification of relevant articles were the following: "extracorporeal membrane transport," "mobile ECMO," and "interhospital transport."

Analytic Plan

After gathering descriptive statistics on mobile ECMO teams between North American and European centers, the

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authors compared the proportion of studies from each continent that reported the inclusion of anesthesiologists in its mobile ECMO teams and the number of cases these studies represented. This difference was analyzed using Fisher exact test, with a 2-sided p value of <0.05 considered significant. The types of complications encountered among transport ECMO teams also were examined. Because these data were not standardized and frequently omitted across the studies analyzed, the authors did not attempt to perform a quantitative analysis of the incidence of complications. Complications were grouped by type in accordance with the descriptions contained in the relevant references. The type of ECMO used (ie, venoarterial [VA] *v* venovenous [VV]) also was reported (Table 1 [4–28]). Finally, data on transport distance were gathered and are summarized herein as ranges. Because many studies did not include full descriptions of the distributions of distance traveled, only ranges are reported because weighted means, which would have accounted for each study's sample size, were not possible to calculate.

RESULTS

A total of 317 articles were identified for screening using the aforementioned search terms in PubMed. Identified articles were published between 1986 and 2015, of which 54 were specifically about mobile ECMO (see Fig 1). Of these 54 articles, the following were excluded: pumpless extracorporeal lung-assist cases (3), single-case reports (3), articles not available in the English language (5), articles not specifying an ECMO team (2), articles from institutions outside of Europe and North America (5), and articles that included overlapping, duplicate data from the same institution (11), leaving a total of 25 included articles for this analysis (see Fig 1)—6 from North American centers and 19 from European centers. In sum, the included articles reported a total of 1,329 cases: 389 (29%) adult-only cohorts and 940 (71%) mixed-age cohorts.

Contrasting North American with European practice, a notable discrepancy was found in the proportion of studies that included an anesthesiologist on the ECMO transport team. Among North American studies, 0 of 6 (0%) reported the presence of an anesthesiologist on the mobile ECMO team in contrast to 10 of 19 (53%) studies from Europe reporting the inclusion of an anesthesiologist on the transport team. (Fisher exact p for difference between proportions by studies was 0.05). In terms of the number of cases, this discrepancy translated to 543 total cases in North America (all without an anesthesiologist) and 499 cases in Europe (37%) incorporating an anesthesiologist on the team (Fisher exact p for difference between proportions by cases was <0.001 [see Table 1]). The inclusions of surgeons, nurses, and perfusionists on the transport team were similar between centers on the 2 continents; they were all reported in 50% or more of the studies. A few studies reported intensivists, but their specialties were unspecified. A complete list of mobile ECMO team members by study is listed in Table 2. [4–28]

Other notable characteristics between the North American and European experience included similar ranges of transport distance (4-12,070 km for North American *v* 1-13,447 km for European cohorts). There was nearly 100% survival during the transport process, with only 1 reported death en route.

In relation to the type of ECMO used in the transported patients, North American studies reported 189 cases of VA ECMO versus 315 cases of VV ECMO, whereas the European studies reported 389 and 94 cases, respectively. It is notable that one of the biggest studies performed in Europe did not report the type of ECMO used in its transported patients.[5]

Regarding complications, due to inconsistent reporting between and within studies, a quantitative representation of the incidence of complications was not possible. This was exemplified by some overlapping studies that reported mutually inconsistent complications. Nevertheless, it still was informative to review the types of complications reported as a qualitative representation of the range of issues encountered during transport ECMO. Although reporting was inconsistent, complications included death, cardiac arrest, arrhythmia, cardiac stun, bleeding, loss of tidal volume, hypothermia, hypotension, bradycardia, equipment malfunction/failure, overinfusion of intravenous drugs, and transportation mishaps such as an airplane landing at the wrong airport (see Table 1). Interestingly, just as critical care patient complications were, as expected, a dominant theme within this qualitative review, electrical and mechanical malfunctions also were highly prevalent among those reported.

DISCUSSION

This study demonstrated significant geographic discrepancies in the inclusion of anesthesiologists in mobile ECMO teams, with European centers much more likely to incorporate an anesthesiologist in the mobile ECMO process compared with centers in North America.

Patients with critical, life-threatening cardiopulmonary conditions refractory to medical therapy require specialized assistance by a team of clinicians in a multispecialty environment.[29] Particularly relevant to this analysis, several of the complications reported in the literature are ones that commonly are encountered in the perioperative environment and for which anesthesiologists are trained to provide lifesaving interventions, including the treatment of hypotension, hypothermia, arrhythmias, tidal volume/airway management, pressor support, equipment failure, and appropriate sedation.

Limitations

The difference in historic practice patterns may not have any relationship to outcomes and simply may reflect the differing role of anesthesiologists between these areas, with the role of anesthesiologist-intensivists much more prominent historically in Europe than in North America.[30] This difference in the role of anesthesiologist-intensivists was reflected in a 2000 study by Angus et al, in which it was reported that anesthesiologist-intensivists in the United States made up 6% of the critical care workforce, and the supply for these specialty-trained individuals was expected to remain stagnant.[31]

Even though some studies in the review presented here reported the experiences in relation to the type of ECMO used, the specificity of reporting was insufficient to determine the related complications stratified by type of ECMO.[20] In