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# Venoarterial extracorporeal membrane oxygenation for patients in shock or cardiac arrest secondary to cardiotoxicant poisoning: A cost-effectiveness analysis ☆

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ABSTRACT

*Purpose:* Venoarterial extracorporeal membrane oxygenation represents an emerging and recommended option to treat life-threatening cardiotoxicant poisoning. The objective of this cost-effectiveness analysis was to estimate the incremental cost-effectiveness ratio of using venoarterial extracorporeal membrane oxygenation for adults in cardiotoxicant-induced shock or cardiac arrest compared with standard care.
*Materials and methods:* Adults in shock or in cardiac arrest secondary to cardiotoxicant poisoning were studied with a lifetime horizon and a societal perspective. Venoarterial extracorporeal membrane oxygenation cost effectiveness was calculated using a decision analysis tree, with the effect of the intervention and the probabilities used in the model taken from an observational study representing the highest level of evidence available. The costs (2013 Canadian dollars, where $1.00 Canadian = $0.9562 US dollars) were documented with interviews, reviews of official provincial documents, or published articles. A series of one-way sensitivity analyses and a probabilistic sensitivity analysis using Monte Carlo simulation were used to evaluate uncertainty in the decision model.
*Results:* The cost per life year (LY) gained in the extracorporeal membrane oxygenation group was $145 931/18 LY compared with $88 450/10 LY in the non-extracorporeal membrane oxygenation group. The incremental cost-effectiveness ratio ($7185/LY but $34 311/LY using a more pessimistic approach) was mainly influenced by the probability of survival. The probabilistic sensitivity analysis identified variability in both cost and effectiveness.
*Conclusion:* Venoarterial extracorporeal membrane oxygenation may be cost effective in treating cardiotoxicant poisonings.



## 1. Introduction

Cardiovascular drugs (eg, calcium channel blockers and other antidysrhythmic drugs) may lead to severe shock or cardiac arrest. Poison control centers report that poisonings secondary to cardiovascular drugs are increasing at a high rate [1]. Venoarterial extracorporeal membrane oxygenation (VA-ECMO) is a treatment option for cardiotoxicant poisoning. *Extracorporeal membrane oxygenation* is defined as "the use of mechanical devices to temporarily support heart or lung function (partially or totally) during cardiopulmonary failure, leading to organ recovery or replacement [2]." In poisonings, VA-ECMO can be provided in addition to standard therapies such as high-dose insulin, calcium, and vasopressors [3].

A systematic review of treatments for cardiotoxicant poisonings revealed that VA-ECMO was one of the most strongly supported interventions in the literature, along with the use of high-dose insulin [3].

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One observational study [4] showed a significantly lower mortality rate in cardiotoxicant-poisoned patients (n = 62) treated with VA-ECMO compared with standard care (52%-14%, $P = .002$) and 3 case series of patients in shock or cardiac arrest [5-7] showed survival with good functional outcomes with the use of this invasive strategy. Nonetheless, despite the increase of ECMO usage since 2004 [8], only 5% of cardiac arrest patients receiving ECMO between 1992 and 2007 had a diagnosis of poisoning [9], suggesting that the potential of this intervention is not being realized in cardiotoxicant poisonings. The cost effectiveness of VA-ECMO for cardiotoxicant poisoning has not been well studied. Vats et al [10] previously identified that the use of venovenous ECMO (VV-ECMO) in pediatric patients with hypoxemic respiratory failure in an American tertiary center resulted in a cost of $4190/life year (LY) gained. In a UK-based multicenter randomized trial comparing conventional management to transfer for consideration of ECMO treatment in adults with severe respiratory failure, a lifetime model predicted the cost per quality-adjusted LY (QALY) of ECMO to be £19 252 (95% confidence interval £7622-£59 200) [11]. However, no study has been performed concerning the use of VA-ECMO in adults poisoned with cardiotoxicants. Before promoting the therapy in guidelines that are currently under development, cost effectiveness needs to be assessed [12].

The objective of this cost-effectiveness analysis was to estimate the incremental cost-effectiveness ratio (ICER) (defined as the difference in costs divided by the difference in effects) from a societal perspective of using VA-ECMO for adults in shock or cardiac arrest secondary to cardiotoxicant poisoning compared with standard care. The model included the likelihood that a patient would need to be transferred to a different facility to receive the treatment.

## 2. Materials and methods

Venoarterial extracorporeal membrane oxygenation cost effectiveness was analyzed using a decision analysis tree from a societal perspective. The population of adults in shock or cardiac arrest secondary to cardiotoxicant poisoning treated in Canadian hospitals was studied with a lifetime horizon, accounting for future medical and nonmedical expenditures when a life is saved [13]. This study was approved by the Research Ethics Board of the University Health Network (Toronto).

We generated a decision model comparing the use of VA-ECMO with standard therapies for patients poisoned with cardiotoxicants in persistent cardiac arrest or severe shock at arrival to the emergency department (ED) (Fig. 1). As defined by Masson et al [4], persistent cardiac arrest was considered as an absence of return to spontaneous circulation after continuous cardiopulmonary resuscitation for at least 30 minutes; whereas, severe shock was described as a persistent arterial hypotension (systolic blood pressure, <100 mm Hg) despite optimal conventional treatment as proposed by Baud et al [14] and associated with more than one of the following criteria: left ventricular ejection fraction assessed by echocardiography of less than 30%, severe hypoxemia ($Pao_2$/fraction of inspired oxygen ratio of <150 mm Hg), and renal failure (urine output of <20 mL/h or creatinine of >13 mg/dL).

### 2.1. Effects

The effectiveness measure was documented in LYs gained based on survival results from a study yielding the highest level of evidence identified in a recent systematic review [6], the study published by

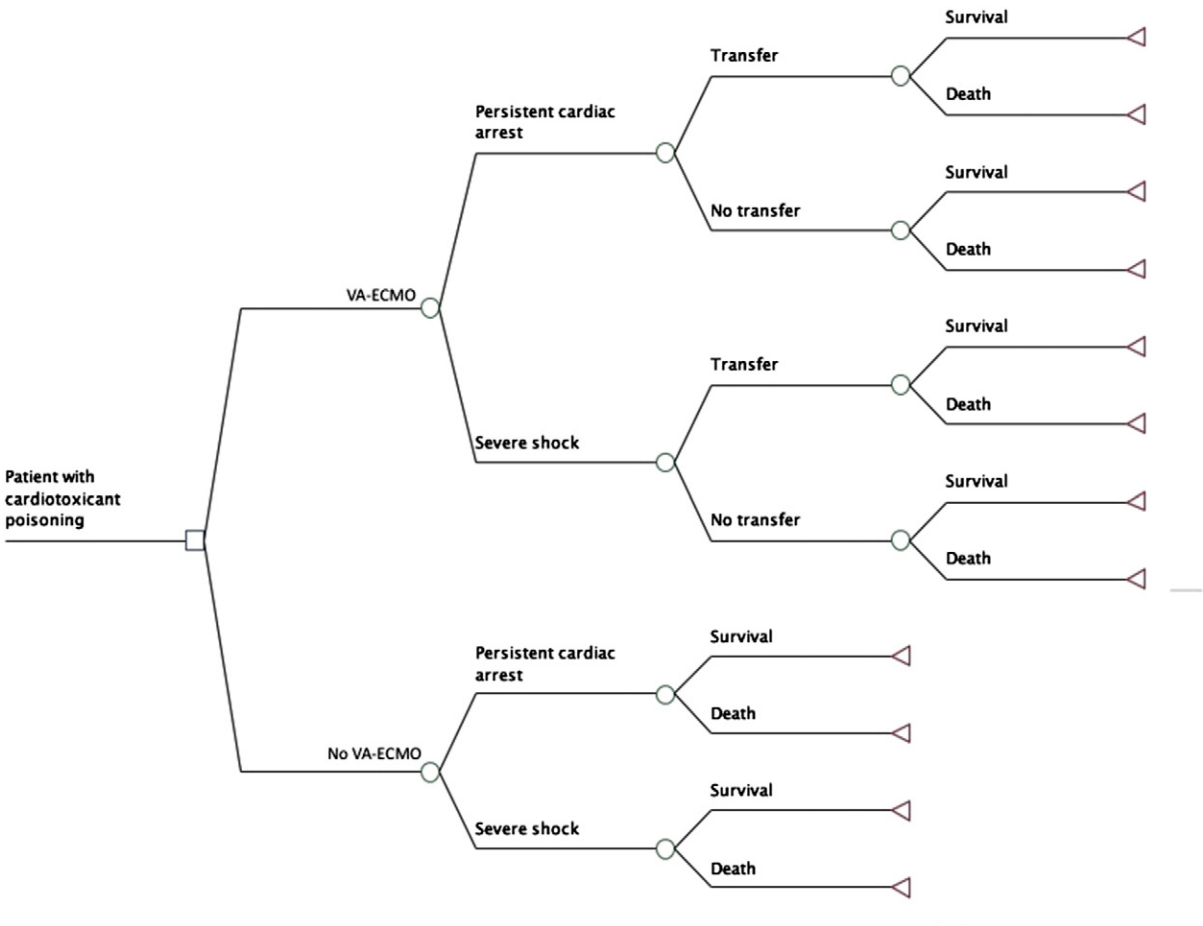


**Fig. 1.** Simplified schema of the decision model. From left to right, the square node represents the decision to use or not use VA-ECMO. The circular nodes represent the downstream consequences of the decision. The triangular nodes at the end of each pathway represent the cumulative costs and effects of each pathway.