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Technology Assessment Unit of the McGill University Health Centre (MUHC)

UPDATE OF TAU REPORT #80:
USE OF EXTRACORPOREAL MEMBRANE OXYGENATION FOR CARDIAC LIFE SUPPORT IN ADULT SUBJECTS

Report number: 90

Brief Report

DATE: April 15, 2022

Report prepared for the Technology Assessment Unit (TAU) of the McGill University Health Centre (MUHC)

by

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Mission Statement

The MUHC Health Technology Assessment Unit (TAU) advises hospital administrators and clinical teams in difficult resource allocation decisions. Using an approach based on independent, critical evaluations of the available scientific evidence and a transparent, fair decision-making process, novel and existing medical equipment, drugs and procedures used by healthcare professionals are prioritized on a continuous basis ensuring the best care for life with the best use of resources.

Brief Reports

Brief reports are prepared in response to urgent requests for information or to update previous reports with new evidence; in such cases an in-depth evaluation is either not possible or is unnecessary. Brief reports are reviewed by the Manager of TAU and the Chair of the Policy Committee, and are only submitted for approval to the Policy Committee if they contain updated recommendations.

Declaration of Conflicts of Interest

Members of TAU's research staff and policy committee declare no conflicts of interest.

Suggested Citation

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- Jeanne Corriveau, Clinical perfusionist, ECMO Program Coordinator of the MUHC
- May Tam, Clinical perfusionist, ECMO Program Coordinator of the MUHC
- André Guigui, Financial analyst, Department of Finance of the MUHC
- Annabelle Nam, Planning, programming and research officer, Department of Finance of the MUHC

REPORT REQUESTOR

This report was originally requested by the chief of the Intensive Care Unit, Dr. Peter Goldberg, and the Director of Quality and Risk Management, Ms. Patricia Lefebvre, on May 11, 2016.

TYPES OF RECOMMENDATIONS ISSUED BY THE TAU COMMITTEE

Type of recommendation	Explanation
Approved	• Evidence for relevant decision criteria, including efficacy, safety, and cost, as well as context-specific factors such as feasibility, is sufficiently strong to justify a recommendation that the technology be accepted, used and funded through the institutional operating budget
Approved for evaluation	• There is a reasonable *probability* that relevant decision criteria, including efficacy, safety, and cost, as well as context-specific factors such as feasibility, are favorable but the evidence is not yet sufficiently strong to support a recommendation for permanent and routine approval. • The evidence is sufficiently strong to recommend a *temporary* approval in a restricted population for the purposes of evaluation, funded through the institutional operating budget.
Not approved	• There is insufficient evidence for the relevant decision criteria, including efficacy, safety, and cost; • The costs of any use of the technology (e.g. for research purposes) should not normally be covered by the institutional budget.

DISCLAIMER

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SUMMARY

BACKGROUND

Extracorporeal membrane oxygenation (ECMO) uses a modified cardiopulmonary bypass system to create an external circuit for the exchange of blood gases, thus helping to prolong the life of patients in acute respiratory or cardiac failure. ECMO configurations include veno-venous (VV) ECMO, which supports lung function primarily, and veno-arterial (VA) ECMO, which supports both cardiac and lung functions. When VA-ECMO is used in conjunction with cardiopulmonary resuscitation (CPR), it is known as ECPR.

OBJECTIVES

The objectives of this report are to assess:

- new evidence on the outcomes of ECMO
- local evidence on the outcomes of ECMO at the MUHC
- the cost and budget of ECMO use at the MUHC
- the establishment of local ECMO protocols and teams at the MUHC

METHODS

We carried out a search for relevant literatures on the outcomes of ECMO published between 2017 and 2021. We obtained information on current use of ECMO at the MUHC from Jeanne Corriveau and May Tam, clinical perfusionists and ECMO Program Coordinators of the MUHC.

FINDINGS

- The international extracorporeal life support (ECLS) registry shows that compared to 5 years ago, the survival rates have remained stable for all types of ECMO.
- MUHC outcomes:
    - By type of ECMO, VV and VA had similar weaning rates, i.e. having ECMO removed and not requiring further mechanical support without resulting in immediate or expected immediate death: 61.1% vs. 63.0%, respectively, while the weaning rate in ECPR cases was 39.6%. The overall weaning rate remained stable compared to 2017 (56.4% vs. 49%, respectively; difference 7%, 95% CI: -9% to 23%).
    - By indications, 53.1% of COVID-19 cases were weaned, whereas 71.0% respiratory failure or distress cases were weaned. The weaning rates were 42.2% for cardiac arrest and 34.6% for cardiac shock.

  - The 30-day survival rate (available for 37 patients from the 2020 period) was 77.8% among male and 60% among female patients. By type of ECMO, VV had the highest 30-day survival rate (80.0%), followed by VA (66.7%) and ECPR (60.0%). Thirty-day survival rates by indication were 87.5% for COVID-19 patients, 80% for cardiogenic shock, 71.4% for respiratory failures, and 66.7% for cardiac arrest. The overall 30-day survival rate among adults in 2020 was 72.7% (24/33) vs. 37.5% (15/40) in 2017 (difference 35.2%, 95% CI: 12.3 to 53.3%).
- MUHC volume and cost:
  - The ECMO volumes and average duration of stays increased substantially in the 2020/2021 period, most likely contributed by the COVID-19 cases. Nonetheless, the average 1-day cost remained stable across the fiscal periods. The overall average 1-day costs were $12,555 for VA-ECMO and $13,305 for VV-ECMO. The total spending on ECMO ranged between $0.9M to $1.4M for the fiscal period 2017/2018-2019/2020 and increased to $2.5M for the 2020/2021 period.
- The pediatric and adult ECMO programs at the MUHC, i.e. Montreal Children's Hospital and Royal Victoria Hospital (RVH), respectively, ensure continuous training and education for its members (nurses, physicians and allied health professionals). At RVH, this program also includes trajectories for ECMO patients, procedures and protocols and a workforce plan. Steps have been taken to have MUHC data accredited by the ELSO registry.

CONCLUSION

- The international extracorporeal life support (ECLS) registry shows that compared to 5 years ago, the survival rates have remained stable across all types of ECMO.
- At the MUHC, ECMO volumes and average duration of stays increased substantially in the 2020/2021 period, most likely contributed by the COVID-19 cases. Nonetheless, the average 1-day cost remained stable across the fiscal periods**.**
- The overall weaning rate has remained stable compared to 2017 (56.4% vs. 49%, respectively). However, the overall 30-day survival rate among adults (n=33) in 2020 has almost doubled compared to the rate in 2017 (n=40) (72.7% vs. 37.5%).
- The ECMO programs at the MUHC have been established. Steps have been taken to have MUHC data accredited by the ELSO registry.

RECOMMENDATION

We conclude that our previous recommendation of Approval for evaluation remains unchanged for ALL types and indications of ECMO. Our recommendation is conditional on:

- procurement of dedicated funding to ease the burden on resources associated with an increase in ECMO use;
- systematic documentation of each case;
- re-evaluation of the evidence as new data, or new technology, become available

SOMMAIRE

CONTEXTE

L'oxygénation par membrane extracorporelle (OMEC) utilise un système de soutien cardiopulmonaire modifié pour créer un circuit externe d'échange des gaz sanguins, contribuant ainsi à prolonger la vie des patients en insuffisance respiratoire ou cardiaque aiguë. Les configurations d'OMEC comprennent l'OMEC veino-veineuse (VV), qui prend principalement en charge la fonction pulmonaire, et l'OMEC veino-artérielle (VA), qui prend en charge les fonctions cardiaque et pulmonaire. Lorsque l'OMEC-VA est utilisée en conjonction avec la réanimation cardiorespiratoire (RCP), elle est connue sous le nom de RCPE.

OBJECTIFS

Les objectifs de ce rapport sont d'évaluer :

- les nouvelles données probantes sur les événements de l'OMEC
- les données probantes locales sur les résultats de l'OMEC au CUSM
- le coût et le budget d'utilisation de l'OMEC au CUSM
- la mise en place de protocoles OMEC locaux et d'équipes au CUSM

MÉTHODOLOGIE

Nous avons effectué une recherche de la littérature pertinente sur les événements de l'OMEC publiés entre 2017 et 2021. Nous avons obtenu des informations sur l'utilisation actuelle de l'OMEC au CUSM provenant de Jeanne Corriveau et May Tam, perfusionnistes cliniques et coordonnatrices du programme d'OMEC du CUSM.

RÉSULTATS

- Le registre international de réanimation extracorporelle (ECLS) montre que les taux de survie sont restés stables pour tous les types d'OMEC comparer à 5 ans auparavant.
- Événements au CUSM :
    - Selon le type d'OMEC, VV et VA avaient des taux de sevrage similaires, c'est-à-dire retirer l'OMEC ne nécessitait pas de soutien mécanique supplémentaire sans entraîner de décès immédiat ou décès attendu immédiat: 61,1 % vs 63,0 %, respectivement, tandis que le taux de sevrage dans les cas de RCPE était 39,6 %. Le taux de sevrage global est resté stable

par rapport à 2017 (56,4 % vs 49 %, respectivement; différence 7 %, IC à 95 %: -9 % à 23 %).

- Selon les indications, 53,1 % des cas de COVID-19 ont été sevrés, tandis que 71,0 % des cas d'insuffisance ou de détresse respiratoire ont été sevrés. Les taux de sevrage étaient de 42,2 % pour les arrêts cardiaques et de 34,6 % pour les chocs cardiaques.
- Le taux de survie à 30 jours (disponible pour 37 patients dans la période 2020) était de 77,8 % chez les hommes et de 60 % chez les femmes. Selon le type d'OMEC, VV avait le taux de survie à 30 jours le plus élevé (80,0 %), suivi de VA (66,7 %) et RCPE (60,0 %). Les taux de survie à 30 jours par indication étaient de 87,5 % pour les patients COVID-19, 80 % pour les chocs cardiogéniques, 71,4 % pour les insuffisances respiratoires et 66,7 % pour les arrêts cardiaques. Le taux de survie global à 30 jours chez les adultes en 2020 était de 72,7 % (24/33) contre 37,5 % (15/40) en 2017 (différence 35,2 %, IC à 95 % : 12,3 à 53,3 %).

- Volume et coût au CUSM:

  - Les volumes d'OMEC et la durée moyenne des séjours ont considérablement augmenté au cours de la période 2020/2021, probablement en raison des cas de COVID-19. Néanmoins, le coût moyen pour une journée est demeuré stable d'une période fiscale à l'autre. Les coûts moyens globaux pour une journée étaient de 12 555 $ pour OMEC-VA et de 13 305 $ pour OMEC-VV. Les dépenses totales pour l'OMEC variées entre 0,9 M$ et 1,4 M$ pour la période fiscale 2017/2018-2019/2020 et augmenté à 2,5 M$ pour la période 2020/2021.

- Les programmes d'OMEC pédiatrique et adulte du CUSM, c'est-à-dire l'Hôpital de Montréal pour enfants et l'Hôpital Royal Victoria (HRV), respectivement, assurent la formation et l'éducation continues de ses membres (infirmières, médecins et professionnels paramédicaux). À l'HRV, ce programme comprend également des trajectoires pour les patients d'OMEC, des procédures et des protocoles et un plan de main-d'œuvre. Des démarches ont été entreprises pour faire accréditer les données du CUSM par le registre ELSO.

CONCLUSIONS

- Le registre international de réanimation extracorporelle (ECLS) montre que, comparer à 5 ans auparavant, les taux de survie sont restés stables pour tous les types d'OMEC.

- Au CUSM, les volumes d'OMEC et la durée moyenne des séjours ont considérablement augmenté au cours de la période 2020/2021, probablement en raison des cas de COVID-19. Néanmoins, le coût moyen pour une journée est demeuré stable d'une période fiscale à l'autre.
- Le taux de sevrage global est resté stable par rapport à 2017 (56,4 % vs 49 %, respectivement). Cependant, le taux de survie global à 30 jours chez les adultes (n=33) en 2020 a presque doublé par rapport au taux en 2017 (n=40) (72,7 % vs 37,5 %).
- Les programmes d'OMEC au CUSM sont déjà établis. Des démarches ont été entreprises pour faire accréditer les données du CUSM par le registre ELSO.

RECOMMANDATIONS

Nous concluons que notre précédente recommandation d'Approbation pour évaluation reste inchangée pour TOUS les types et indications d'OMEC. Notre recommandation est conditionnelle à:

- l'obtention de fonds dédiés pour alléger la charge sur les ressources associées à une augmentation de l'utilisation de l'OMEC;
- une documentation systématique de chaque cas;
- une réévaluation des données probantes à mesure que de nouvelles données ou de nouvelles technologies deviennent disponibles.

LIST OF ABBREVIATIONS

ARDS	Acute respiratory distress syndrome
CI	Confidence interval
ECLS	Extracorporeal life support
ECMO	Extracorporeal membrane oxygenation
ECPR	Extracorporeal membrane oxygenation during cardiopulmonary resuscitation
ELSO	Extracorporeal Life Support Organization
HTA	Health technology assessment
ICU	Intensive care unit
MUHC	McGill University Health Centre
MV	Mechanical ventilation
TAU	MUHC Technology Assessment Unit
VAD	Ventricular assist device
VA-ECMO	Veno-venous extracorporeal membrane oxygenation
VV-ECMO	Veno-arterial extracorporeal membrane oxygenation

UPDATE OF TAU REPORT #80: USE OF EXTRACORPOREAL MEMBRANE OXYGENATION FOR CARDIAC LIFE SUPPORT IN ADULT SUBJECTS

1. BACKGROUND

Extracorporeal membrane oxygenation (ECMO) uses a modified cardiopulmonary bypass system to create an external circuit for the exchange of blood gases, thus helping to prolong the life of patients in acute respiratory or cardiac failure. ECMO configurations include veno-venous (VV) ECMO, which supports lung function primarily, and veno-arterial (VA) ECMO, which supports both cardiac and lung functions. When VA-ECMO is used in conjunction with cardiopulmonary resuscitation (CPR), it is known as ECPR.

1.1 Reason for Brief Report

This brief statement is to update the recommendations issued in TAU report #80 (June 2017), which evaluated the effectiveness and safety of ECMO [1]. At the time of that report, there were no published randomized controlled trials of VA-ECMO. There was a suggestion of improved survival with ECPR compared with conventional CPR for in-hospital and out-of-hospital cardiac arrest. Nevertheless, data on survival rates for VA-ECMO relative to alternative options were inconclusive. In addition, there were no clear normative guidelines for indications of ECMO use due to the heterogeneous study population and limited body of evidence on clear indicators for survival. In terms of cost, the estimated total cost in 2017 of treating the next 20 patients with VA-ECMO was $361,211, assuming each patient spent 3 days on ECMO. The estimated budget impact (additional costs incurred by the use of ECMO) of treating a patient with VA-ECMO for 3 days was $13,289.35. At the time of the 2017 TAU report, a designated ECMO team at the adult MUHC sites had not yet been created. Such an ECMO team would lead to faster deployment of ECMO, greater efficiency, and possibly improved clinical outcomes. Therefore, the TAU committee recommended an Approval for evaluation for ECMO use at the MUHC.

2. OBJECTIVES

The objectives of this report are to assess:

- new evidence on the outcomes of ECMO
- local evidence on the outcomes of ECMO at the MUHC
- the cost and budget of ECMO use at the MUHC
- the establishment of local ECMO protocols and teams at the MUHC

3. METHODS

3.1 Literature search and quality assessment

We carried out a search for relevant literatures on the outcomes of ECMO published between 2017 and 2021.

3.2 MUHC experience

We obtained information on current use of ECMO at the MUHC from Jeanne Corriveau and May Tam, clinical perfusionists, ECMO Program Coordinators of the MUHC. We obtained information on the cost of ECMO from André Guigui and Annabelle Nam from the Department of Finance, McGill University Health Centre.

4. RESULTS

4.1 International ECMO Registry

The Extracorporeal Life Support Organization (ELSO) Registry is an international ECMO registry with data for more than 125,000 patients from 50 countries around the world. Survival was defined as (1) cases who recovered and were removed from life support (i.e. weaned off extracorporeal life support [ECLS]), or (2) survived to hospital discharge. A report with data through 2020 from the ELSO Registry suggests that survival following VV-ECMO in an adult population of 34,319 total runs (run = each time a patient is put on ECMO) was 67% to weaning and 59% to discharge (Table 1) [2]. Survival following VA-ECMO in 33,115 total runs was 59% to weaning and 44% to discharge. Survival following ECPR in 10,324 total runs was 41% to weaning and 30% to discharge. The survival rates are stable compared to the ELSO statistics in 2016, where survival to discharge in adults patients were 58% for VV-ECMO, 41% for VA-ECMO, 29% for ECPR [3].

4.2 ECMO Use for COVID-19 Cases

In the wake of COVID-19 pandemic, ECMO support has been recommended for COVID-19-related acute hypoxaemic respiratory failure. A study that used ELSO Registry data to evaluate in-hospital death in a time-to-event analysis assessed outcomes at 90 days after ECMO initiation among patients with COVID-19 aged 16-years and older[4]. Of 1035 patients, 37% died and 63% survived with the following breakdown: 6% remained hospitalised, 30% were discharged home or to an acute rehabilitation centre, 10% were discharged to a long-term acute care centre or unspecified location, and 17% were discharged to another hospital. In 968 patients with a final disposition of death or hospital discharge, the mortality was 39%. In the subset of patients VV-ECMO and characterised as having acute respiratory distress syndrome, the estimated cumulative incidence of in-hospital mortality 90 days after the initiation of ECMO was 38.0% (95% CI 34.6–41.5).

4.3 MUHC experience with ECMO

While the Montreal's Children Hospital (MCH) has an established ECMO program, introduced in 1991, to support children with heart/lung failure refractory to conventional therapies, the use of ECMO in adults at MUHC was started in May 2013. Prior to 2018, paediatric cases treated at the MUHC were computed in the MCH database. This explains the low number of paediatric cases in the MUHC database.

4.3.1 Outcomes

Between January 2017 and July 2021, 197 patients were supported with ECMO (after excluding 19 patients who were on ECMO for less than 1 hour and five cases with right ventricular assisted devices). There were 9 patients who had multiple ECMO procedures (back-to-back) and we only included their last procedure in our analysis.

Of these 197 patients, VV-ECMO was the most common type (45.7%), followed by VA-ECMO (27.4%) and ECPR (26.9%). Eleven (5.2%) procedures were done in paediatric patients and 139 (70.6%) were done in males (Table 2).

By indications, 36.0% VV-ECMO was done in COVID-19 cases while the majority (80.8%) of ECPR was done in cardiac arrest cases. The number of VV-ECMO use in 2020 almost doubled the use in 2019 due to COVID-19.

Weaning Rates

Weaning was defined as those having ECMO removed and not requiring further mechanical support without resulting in immediate or expected immediate death. Patients who were transitioned to another mechanical support without outcome information were kept in a separate category. The weaning rates were 53.7% among males and 64.4% among females (Table 3). Weaning rate by age was 81.8% among paediatric cases and 54.3% among adults. This is in line with the ELSO registry statistics where paediatric cases have a significantly higher survival rate than adults [3].

By type of ECMO, VV and VA had similar weaning rates (61.1% vs. 63.0%, respectively) while the weaning rate in ECPR cases was 39.6%. The overall weaning rate was stable compared to 2017 (56.4% vs. 49%, respectively, difference 7% 95% CI -9% to 23%). The weaning rate for VV-ECMO was lower than the recent ELSO rate [2] (61% vs. 77%, difference 16% , 95% CI 5.9-26.1%). The differences in VA-ECMO and ECPR weaning rates were not significant. Nonetheless, it is important to note that ELSO uses total runs instead of total patients as their denominator.

By indications, 53.1% of COVID-19 cases were weaned, whereas 71.0% of respiratory failure or distress cases were weaned. The weaning rates were 42.2% for cardiac arrest and 34.6% for cardiac shock.

Survival Rate

Of 197 patients, survival at 30 days was available in 37 patients from the 2020 period (Table 4). The survival rate was 77.8% among male and 60% among female patients. By type of ECMO, VV had the highest survival rate (80.0%), followed by VA (66.7%), and ECPR (60.0%). Thirty-day survival rates by indication were 87.5% for COVID-19 patients, 80% for cardiogenic shock, 71.4% for respiratory failures, and 66.7% for cardiac arrest. The overall 30-day survival rate was 72.7% among adults, almost double the 38.0% rate in 2017 [1] (difference 34.7%, 95%CI 11.9% to 52.7%).

4.3.2 ECMO teams and programs

The MUHC currently employs 10 perfusionists; the ideal number would be 11. The percentage of perfusionist hours spent on ECMO has increased; nonetheless, cardiac cases or catheterization laboratory procedures have never been cancelled due to the increased ECMO load. The ratio of perfusionists to ECMO has also increased to be able to take care of multiple ECMO cases at the same time.

Introduced in 1991, the Montreal Children's Hospital (MCH) has had a well-established ECMO program, which ensures continuous training and education for its members (training sessions every 2 months). At the Royal Victoria Hospital (RVH, adult sites), the eCPR program was started in 2016. In the ICU, there is an ECMO team (Dr. Samoukovic, ECMO fellows, and perfusionists) in addition to the regular treating team. Furthermore, there is 24-hour coverage by perfusionists and cannulators on-call for emergent need of ECMO. The continuing education program was launched at the end of 2021 with protocols and procedures specific to the adult population. The RVH ECMO program includes a didactic and hands-on training program for nurses, physicians and allied health professionals. This program also includes trajectories for ECMO patients, procedures and protocols and a workforce plan. Not all the above has been implemented yet but the global proposal was accepted. Steps have been taken to have MUHC data accredited by the ELSO registry.

4.3.3 Current treatment policy

The ELSO guidelines have been followed for patient indication, but it remains at the physician's discretion whether or not to put a patient on ECMO. A reference sheet describing patient indications, course of action, plan and positioning, and the role of the emergency department staff are included in the Appendix A.

4.4 Cost of ECMO use at the MUHC

From March 2013 to September 2016, spending on the 41 adults supported with ECMO at the MUHC was $765,149. The average 1-day cost was $12,242 for VA-ECMO and $12,992 for VV-ECMO[1].

For the fiscal periods from May 2017 to April 2021, 184 patients were treated with ECMO. The ECMO volumes and average duration of stays increased substantially in 2020/2021 period, most likely contributed by the COVID-19 cases. Nonetheless, the average 1-day cost remained stable across the fiscal periods (Table 5). The overall average 1-day cost was $12,555 for VA-ECMO and $13,305 for VV-ECMO. The total spending on ECMO ranged between $0.9M to $1.4M for the fiscal period 2017/2018-2019/2020 and increased to $2.5M for 2020/2021 period.

5. CONCLUSIONS

- The international extracorporeal life support (ECLS) registry shows that compared to 5 years ago, the survival rates have remained stable across all types of ECMO.

- At the MUHC, ECMO volumes and average duration of stays increased substantially in the 2020/2021 period, most likely contributed by the COVID-19 cases. Nonetheless, the average 1-day cost remained stable across the fiscal periods**.**
- The overall weaning rate at the MUHC has remained stable compared to 2017 (56.4% vs. 49% respectively). However, the overall 30-day survival rate among adults almost doubled the rate in 2017 (72.7% vs. 38% respectively).
- The ECMO programs at the MUHC have been established. Steps have been taken to have MUHC data accredited by the ELSO registry.

6. RECOMMENDATIONS

We conclude that our previous recommendation of Approval for evaluation remains unchanged for ALL types and indications of ECMO and are conditional on:

- procurement of dedicated funding to ease the burden on resources associated with an increase in ECMO use;
- systematic documentation of each case;
- re-evaluation of the evidence as new data, or new technology, become available

TABLES

Table 1. The survival rates of ECMO in neonatal, paediatrics, and adult populations from the International Registry report

	Total Runs	Survived to weaning off ECLS		Survived to discharge or transfer	
	N	N	%	n	%
Neonatal	45,365	37,568	83	29,636	65
Pulmonary (VV-ECMO)	33,484	29,332	87	24,457	73
Cardiac (VA-ECMO)	9,620	6,648	69	4,218	43
ECPR	2,261	1,588	70	961	42
Paediatric	30,983	21,705	70	16,786	54
Pulmonary (VV-ECMO)	11,223	8,122	72	6,775	60
Cardiac (VA-ECMO)	14,078	10,204	72	7,594	53
ECPR	5,682	3,379	59	2,417	42
Adults	77,758	47,296	61	38,198	49
Pulmonary (VV-ECMO)	34,319	23,254	67	20,320	59
Cardiac (VA-ECMO)	33,115	19,727	59	14,765	44
ECPR	10,324	4,315	41	3,113	30
Total	154,106	106,569	69	84,620	55
Pulmonary (VV-ECMO)	79,026	60,708	77	51,552	65
Cardiac (VA-ECMO)	56,813	36,579	64	26,577	47
ECPR	18,267	9,282	51	6,491	36

Table 2. Distribution of types of ECMO by sex, age, and indications at the MUHC in 2017-2021

Characteristics	Value	ECPR N=53	VA N=54	VV N=90
Sex	Male	38 (71.7)	36 (66.7)	65 (72.2)
	Female	15 (28.3)	18 (33.3)	25 (27.8)
Age category	Paediatrics	1 (1.9)	9 (16.7)	1 (1.1)
	Adults	52 (98.1)	45 (83.3)	89 (98.9)
Indications	Cardiac Arrest	42 (80.8)	3 (5.6)	0 (0)
	Cardiogenic shock or failure	3 (5.8)	23 (42.6)	0 (0)
	COVID-19	0 (0)	0 (0)	32 (36.0)
	Respiratory failure or distress	1 (1.9)*	0 (0)	30 (33.7)
	Others	6 (11.5)	28 (51.9)	27 (30.3)
Year of treatment	Jan-Dec 2017	5	4	10
	Jan-Dec 2018	16	11	4
	Jan-Dec 2019	8	15	19
	Jan-Dec 2020	16	14	33
	Jan-July 2021	8	10	24

*This subject had ECPR-VV-VA

Table 3. Weaning rate by sex, age, types and indications of ECMO

Characteristics	Value	Dead (n=76)	Weaned (n=110)	Transition to VAD Support* (n=11)
Sex	Male	58 (41.7)	73 (52.5)	8 (5.8)
	Female	18 (31.0)	37 (63.8)	3 (5.2)
Age category	Paediatrics	2 (18.2)	9 (81.8)	0 (0)
	Adults	74 (39.8)	101 (54.3)	11 (5.9)
ECMO types	ECPR	28 (52.8)	21 (39.6)	4 (7.5)
	VA	13 (24.1)	34 (63.0)	7 (13.0)
	VV	35 (38.9)	55 (61.1)	0 (0)
Indications	Cardiac Arrest	23 (51.1)	19 (42.2)	3 (6.7)
	Cardiogenic shock	10 (38.5)	9 (34.6)	7 (26.9)
	COVID-19	15 (46.9)	17 (53.1)	0 (0)
	Respiratory failure or distress	9 (29.0)	22 (71.0)	0 (0)
	Others	17 (27.9)	43 (70.5)	1 (1.6)

* These patients were transitioned to another mechanical support without outcome information were kept in a separate category

Table 4. Survival rate by sex, age, types and indications of ECMO in 2020 period

Characteristics	Value	Dead N=9	Survived N=27	Transition to VAD Support* N=1
Sex	Male	5 (18.5)	21 (77.8)	1 (3.7)
	Female	4 (40.0)	6 (60.0)	0 (0)
Age category	Paediatrics	1 (25.0)	3 (75.0)	0 (0)
	Adults	8 (24.2)	24 (72.7)	1 (3.0)
ECMO types	ECPR	1 (20.0)	3 (60.0)	1 (20.0)
	VA	4 (33.3)	8 (66.7)	0 (0)
	VV	4 (20.0)	16 (80.0)	0 (0)
Indications	Cardiac arrest	1 (16.7)	4 (66.7)	1 (16.7)
	Cardiogenic shock	1 (20.0)	4 (80.0)	0 (0)
	COVID-19	1 (12.5)	7 (87.5)	0 (0)
	Respiratory failure or distress	2 (28.6)	5 (71.4)	0 (0)
	Others	4 (36.4)	7 (63.6)	0 (0)
Total		9 (24.3)	27 (73.0)	1 (2.7)

* These patients were transitioned to another mechanical support without outcome information were kept in a separate category.

Table 5. ECMO costs at the MUHC for Fiscal Year 2017/2018 through 2020/2021

Fiscal year	ECMO Volumes	Average Duration of ECMO (Days)	Average Perfusionist Cost of ECMO	Avg ICU Nurse Cost	Avg ECMO Personnel Costs	Avg 1-day ECMO Personnel Costs	Avg 1-days VA personnel costs + device +cannula	Avg 1-days VV personnel costs + device +cannula	Estimated Total Costs*
17-18	29	7.2	12,163.9	10,455.6	22,619.5	3,146.9	12,346.9	13,096.9	944,516.8
18-19	38	5.0	13,164.4	7,309.9	20,474.3	4,074.3	13,274.3	14,024.3	1,156,122.4
19-20	**49**	**5.4**	**10,100.6**	**7,872.7**	**17,973.2**	**3,320.9**	**12,520.9**	**13,270.9**	**1,368,238.5**
20-21	68	8.2	14,388.6	11,975.8	26,364.4	3,202.3	12,402.3	13,152.3	2,469,381.0
Overall	184	6.7	12,643.2	9,679.9	22,323.1	3,354.6	12,554.6	13,304.6	5,938,258.6

* assuming all VV-ECMO, which was the most frequently used

REFERENCES

1. Almeida, N. Saab, L. Dendukuri, N., *Use of Extracorporeal Membrane Oxygenation for Cardiac Life Support in adult subjects . Montreal (Canada)*. 2017, Technology Assessment Unit (TAU) of the McGill University Health Centre (MUHC): Montreal (Canada). p. 69.

2. *ECLS Registry Report, International summary*. 2021, Extracorporeal Life Support Organization: Ann Arbor, Michigan, USA.

3. *ECLS Registry Report, International summary*. 2016, Extracorporeal Life Support Organization: Ann Arbor, Michigan, USA.

4. Barbaro, R.P., et al., *Extracorporeal membrane oxygenation support in COVID-19: an international cohort study of the Extracorporeal Life Support Organization registry.* Lancet, 2020. **396**(10257): p. 1071-1078.

APPENDIX

APPENDIX A: ECMO PROTOCOL AT THE MUHC

Code ECMO - Adult – RVH Emergency Department

REFERENCE SHEET

What is it?

Extra**C**orporeal **M**embrane **O**xygenation (ECMO) is a form of life support that supports lungs and/or circulation. It is used to temporarily support gas exchange and/or perfusion in patients with respiratory and/or cardiac failure refractory to conventional therapy.

ECMO Veno-Arterial
for severe circulatory compromise or refractory cardiac arrest; provides oxygenation (gas exchange) and systemic circulation support.

ECMO Veno-Venous
for severe respiratory failure; accesses and returns blood from venous system and provides non-pulmonary oxygenation as well as CO_2 elimination.

What are the patient criteria?

For V-A Cannulation

Exclusion:

- Age > 65 ⇐ (Or at the discretion of the treating physician, particularly in those undergoing a cardiac surgical procedure or a cath lab intervention and this is deemed appropriate by the treating surgeon / interventionalist).
- Weight > 140 kg
- Malignancy stage II or higher (cancer, other than non-melanoma skin, or graft-versus-host disease of the lung)
- Septic patients without cardiac dysfunction
- Advanced liver cirrhosis (Childs B or higher)
- Aortic dissection and/or Severe aortic insufficiency
- Unwitnessed arrest or known poor neurologic status
- Witnessed arrest where resuscitation efforts have been performed for longer than 75 min without ROSC (time to cannulation)
- Severe pulmonary hypertension ⇐ (Unless bridge to transplantation)
- Presence of mechanical cardiac valves ⇐ (Unless bridge to cardiac surgical intervention/transplantation)
- Expressed wishes against mechanical circulatory support (MCS)
- Where cannulation is technically not feasible

Inclusion :

- Cardiac arrest due to MI / cardiac dysfunction / circulatory collapse
- Massive / submassive pulmonary / amniotic fluid embolism
- Post-cardiotomy inability to separate from CPB
- High risk cath lab procedures where more than temporary LVAD "back-up" is needed
- Sepsis with myocardial depression and LVEF<40% and/or Cardiac index inadequate for the patient's hemodynamic needs
- Any other indication at discretion of the treating physician

For V-V Cannulation

For information only
Not inserted in ED

Exclusion:

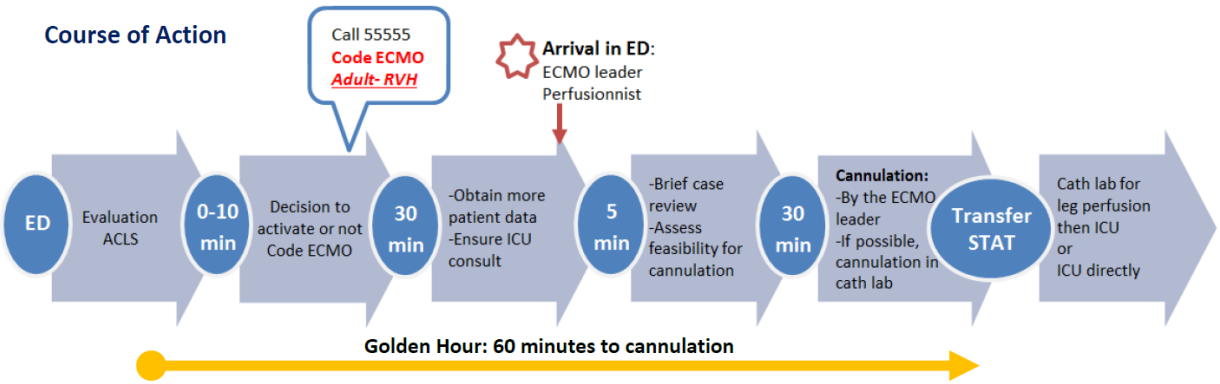
- Age >75 years
- Weight >140 kg
- Non-recoverable pulmonary (including severe pulmonary hypertension), cardiac (severe RV failure and/or severe LV failure) or neurologic status
- Active malignancy (stage II or higher cancer, other than non-melanoma skin), or graft-versus-host disease of the lung
- Childs B or higher liver disease
- Wishes against MCS
- Technical inability to cannulate
- Cardiac arrest, unless attributed purely to hypoxemia

Example of suitable pathological processes:

Common
- Severe pneumonia / ARDS
- Acute lung (graft) failure following transplant
- Pulmonary contusion

Other
- Alveolar proteinosis
- Smoke inhalation
- Status asthmaticus
- Airway obstruction
- Aspiration syndromes

Course of Action



How to activate the code?

Call locating at 55555, for **Code ECMO-*Adult*** at the **Glen -RVH Emergency**.

Report to include:
- Patient Name, #MRN (if available)
- Reason of admission
- Name ED physician
- Extension U/C

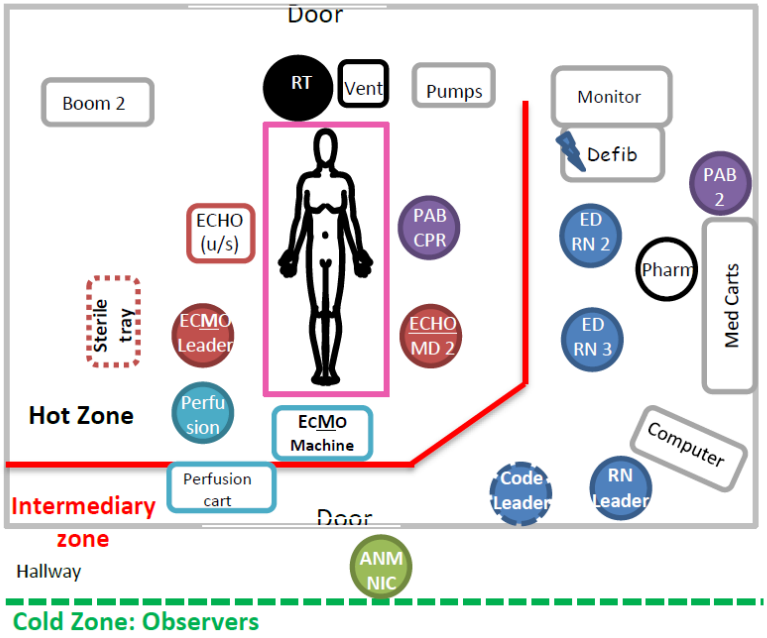
After activation, who will arrive to the ED?

Expected to arrive **within 30 minutes after the call:**

1) ECMO leader and second MD) **2)** Perfusionnist(s) **3)** ICU consultant (if not consulted before).

Plan & positioning (for VA)

Avoid Overcrowding



REMINDERS

1. Stretcher placed between pink tape on the floor.

2. Left boom as far as possible to the left.

3. Defibrillator under the right boom.

4. Hallway is for other professionals helping:
- nurses
- consultants
- PAB

5. Outer limit of the hallway= observer zone

What is the role of the ED Staff?

ED Code Leader

- Initially, code leader is the ED MD. Once patient is on ECMO, can be replaced by member of ECMO team.
- Responsible of ACLS/resuscitation maneuvers, intubation as per protocol.
- Medication prescriptions
- Eligibility assessment for ECMO
- Decision-maker for the activation of code ECMO
- Line insertion (<u>except</u> femoral areas)

ED Nurse Leader

- Code co-leader

Responsible for the care of patient:

- Monitor changes in vital signs or signs of hemodynamics instability
- Place O_2 sat on RIGHT hand
- Monitor complications (bleeding at site or other, ischemic leg)
- Draw labs, type & screen/crossmatch (Write "ECMO" on request, call Blood Bank and inform of priority request for ECMO patient)

Administration of:

- Blood transfusion, fluids, antibiotics prn
- Anticoagulation (heparin bolus IV push)
- ACLS drugs
- Vasoactive drips

Accompanies patient during transport, Ensure electrical plug and space for ECMO machine

ANM- NIC

- Support and relocate staff to ECMO cases (if needed)
- Coordination of ICU transfer
- Assist documentation of major decision

ECMO Leader

- Responsible for cannulation
- Leader is the main decision-maker for all ECMO related issues (except termination of therapy which should be done in ICU)
- Works with ECHO MD (could also be second experienced cannulator)

Perfusionnist

- Set up and manage ECMO machine
- 1 or 2 to assist ECMO leader with cannula insertion.
- Assist in evaluating insertion site/ patient extremities.
- May suggest labs, blood, resuscitation fluid
- Secure ECMO lines for/ during transport

ECHO MD 2

PAB

- CPR as indicated by ED MD and then ECMO leader during cannulation.
- Unclutter room and retrieve equipment.
- Transport patient to cath lab or ICU

RT

- Set up and assist with intubation
- Secure artificial ventilation for /during transport
- Monitor and ensure adequate ventilation

U/C

- May be asked to call locating 55555 & provide report
- Family to be directed to the family room (R-62) and ensure outter resus room are close at all times
- Contact CNS, Educator or spiritual services for family support.
- Assist with phone call to locating & sending requests for blood bank/ central lab and informing priority request.

Nursing Documentation

- Nurses will document care delivered throughout the resuscitation:
  1. Initial arrest rhythm, ACLS maneuvers, patient status; cardiac response
  2. Communication & decision (e.g. to activate, to transfer)
  3. Time: ☐Time **cardiac arrest** ☐Time **activation** of code ECMO ☐Time ECMO **team arrival** to ED ☐Time ECMO **therapy started** in ED ☐Time **transfer out** of ED
  4. ECMO: insertion sites, type of therapy (VA/ VV), anticoagulation, and any fluids given to prevent ECMO suction events.
- Nurses do <u>not</u> document on the ECMO machine data (e.g. flow, sweep gas, etc.), which is performed by the perfusionnist.

Patient Transfer to Cath lab or ICU:

- The team (ED RN [2], ECMO leader, Perfusion, RT, PAB, and ICU MD) escorts patient.
- Report given to the cath lab or ICU nurse.
- Nurses and PAB do not stay for the cath lab procedure or in ICU. They are to return to the ED promptly.

Debriefing

- ANM/NIC to gather ED personnel and lead a 5-10 minutes debriefing.
- ANM/NIC to complete "ECMO Case Summary & Debriefing" form and detail the events to NM by email <u>within a 3 day deadline</u>.

Created by Christine Echegaray-Benites, Clinical Nurse Specialist ED RVH

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