A NURSING TOOLKIT FOR THE BEDSIDE INITIATION OF EXTRACORPOREAL MEMBRANE OXYGENATION (ECMO) IN THE CORONARY CARE UNIT

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Abstract

A nursing knowledge gap in bedside veno-arterial extracorporeal membrane oxygenation (VA-ECMO) initiation was identified in a Coronary Care Unit (CCU). To address this lack of knowledge, an integrative literature review, environmental scan, and workplace consultations were conducted to create a nursing toolkit for bedside initiation of extracorporeal membrane oxygenation (ECMO). From the literature review and environmental scan, 34 articles, clinical practice guidelines, and clinical resources were identified. Data were extracted, and content analysis was used to generate categories. These categories included: patient inclusion and exclusion criteria, indications and contraindications to ECMO initiation, considerations for each phase of ECMO cannulation (pre-, during, and post-), potential complications, and patient outcomes. Consultations were conducted with four staff members within the New Brunswick Heart Centre, including three CCU nursing staff and one physician. An interview and focus group were used to collect data through open-ended questions. Content analysis was used to analyze the extracted data to generate eleven categories. The results from both the literature review/environmental scan and the consultations guided and informed the development of the content and format of the nursing toolkit. A booklet of bedside checklists and a video-recorded PowerPoint presentation were created to inform nursing staff of the process of bedside ECMO cannulation. The completed checklists and PowerPoint presentation were sent to the consultants for review. A plan for the dissemination of the toolkit was then outlined. By conducting this practicum project, an informative resource was created to guide nursing practice in the CCU.

Keywords: ECMO, ECLS, bedside cannulation, extracorporeal, clinical practice guidelines

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Introduction

While working in the coronary care unit (CCU) at the Saint John Regional Hospital (SJRH), I have noted areas requiring resources to inform and support safe nursing practice. Through an informal discussion with the nurse educator for the New Brunswick Heart Centre, a need for a resource to prepare and inform CCU nurses of the emergent bedside initiation of extracorporeal membrane oxygenation (ECMO) was identified. Normally, this procedure would be performed by the cardiovascular surgeon and the operating room (OR) team. However, the nurse educator noted that on multiple occasions, the OR team has not been available, and the nurses in CCU have assisted the surgeon with the initiation of ECMO. This is in addition to managing the patient's hemodynamic instability and potential cardiac arrest. Nurses I have worked with have expressed uncertainty with the procedure and unclear responsibilities of the CCU team. Therefore, I have decided to address this issue through the development of an education resource in the form of a toolkit. This will provide CCU nurses with information to familiarize themselves with the procedure should they need to care for a patient who requires bedside ECMO cannulation. In this practicum project, I describe the objectives, planning, and creation of a bedside ECMO nursing toolkit, as well as the nursing competencies I have met throughout this process.

To begin, ECMO is an advanced, invasive therapy used to treat multiple cardiovascular and respiratory conditions, such as cardiogenic shock, cardiomyopathy, and pulmonary hypertension (Extracorporeal Life Support Organization [ELSO], n.d.). This therapy supports the heart and/or lungs by oxygenating and pumping blood through a circuit and back to the body via two veins or a vein and an artery (ELSO, n.d.). As each ECMO-capable centre's needs and team structures are different, it is recommended that a unique program for educating nursing staff be

created by each centre (Mossadegh & Combes, 2017). With such a high level of acuity, it is critical that nurses understand their role within the team, especially when having to scrub in to assist with insertion, manage hemodynamic instability or a cardiac arrest during ECMO insertion, and ensure safe transportation once ECMO is placed. To support nurses and other team members in providing safe care to every patient who requires this therapy, the creation of a standardized protocol may be beneficial.

Objectives

The overall goal of this practicum project was to develop a toolkit to be used by critical care registered nurses to inform practice regarding the initiation of ECMO at the bedside in CCU prior to transfer to the OR, cardiac catheterization lab, or surgical ICU. The key practicum objectives were:

1. Describe the process, nursing considerations, and patient concerns regarding initiation of bedside ECMO through an integrative literature review
2. Identify current policies and practice recommendations for bedside ECMO initiation through an environmental scan
3. Identify the type of resource that would be useful and applicable to the CCU at the SJRH through consultations with key collaborators
4. Develop a resource or toolkit based on the identified needs and current guidelines
5. Demonstrate advanced nursing practice competencies

Overview of Methods

An integrative review was combined with an environmental scan in order to gain a broader perspective for the creation of the nursing resource and clinical practice protocol. This approach allowed for an integrated synthesis of empirical evidence and current clinical protocols.

Therefore, the resulting knowledge base was an updated reflection of scientific literature and the current state of environmental readiness. By combining an integrative review and environmental scan, a diverse knowledge base was developed from which the resource could be created.

After the literature review and environmental scan were completed, consultations were conducted with key collaborators from the CCU at the SJRH. The consultations were used to gather information specific to the hospital for which this resource would be developed. This allowed me to cater to the needs of the unit regarding the information included in, and the format of, the toolkit. The format of the consultations included a focus group with three nurses and an interview with a physician.

Once the consultations were completed and analyzed, the framework for the toolkit was developed. Recommendations for content and format were combined with the results from the literature review and environmental scan to create the nursing toolkit and clinical practice protocol. This included a booklet of checklists to be used at the bedside and a video PowerPoint presentation about ECMO and the bedside cannulation process. The PowerPoint presentation and the booklet were sent via email to the key collaborators for feedback. Feedback was then integrated into the toolkit, and a finalized copy was sent to the consulted physician and the resource nurse for final remarks.

Finally, options for future implementation and evaluation of the toolkit were created, as outlined in this paper. A finalized copy of the bedside-checklist booklet, the PowerPoint presentation, and the video presentation were sent to the resource nurse for dissemination. Additionally, there have been discussions about collaborating with the simulation team for Horizon Health Network to test the effectiveness of the bedside checklists. With this, there have been discussions about submitting the results for publication.

Summary of the Literature Review and Environmental Scan

In order to gather evidence-based information for the basis of the nursing toolkit, a literature review and environmental scan were conducted (see Appendix A). The two were combined to simultaneously synthesize empirical evidence and clinical practice guidelines/resources. This provided a broader perspective on bedside ECMO cannulation and ECPR on which to base the toolkit.

A total of six databases (i.e., Embase, PubMed, Google Scholar, CINAHL, Cochrane, and Ovid MEDLINE) and one organizational website (Extracorporeal Life Support Organization) were searched for clinical practice guidelines and empirical evidence on bedside ECMO cannulation. Search terms used included combinations of nurs*; ECMO or extracorporeal membrane oxygenation; ECLS or extracorporeal life support; bedside cannulation; catheterization; insert; cannula*; placement*; emerg* or ED; operating room or OR; intensive care unit or ICU; and patients' rooms. My academic advisor and a librarian were consulted for assistance with search strategies. Search limits for the articles included publication within the last 10 years (January 2015 to September 2025), full text in English available, and review articles only. Furthermore, 17 contacts from 8 Canadian ECMO-capable centres were contacted via email to gather available nursing resources pertaining to bedside ECMO cannulation (i.e., Foothills Medical Centre, Mazankowski Heart Institute, Halifax Infirmary - Queen Elizabeth II Health Sciences Centre, St. Boniface Hospital, Toronto General Hospital, Jewish General Hospital, Vancouver General Hospital, and Saint John Regional Hospital). There was no response from five contacts, and eight contacts responded that they did not currently have a resource developed for informing nursing practice in bedside ECMO cannulation. The final four contacts provided nursing resources currently used at their facility (a total of three resources).

This demonstrated the lack of standardized nursing toolkits nationally.

From these sources, 79 articles were included for full-text screening (narrative reviews and clinical practice guidelines) and 3 resources were provided by 3 ECMO centres. The articles/clinical practice guidelines had a focus on the adult population, the peri-cannulation period, and VA-ECMO/ECPR. Articles and guidelines that did not meet these criteria were excluded. For the final review, 31 articles and 3 resources were included. Direct quotations were extracted into separate data extraction sheets (reviews, guidelines, resources), and key article and resource information were summarized in literature summary tables (see Appendix A). Content analysis was used to conduct data analysis (Elo & Kyngäs, 2008; Kleinheksel et al., 2020; Meier, 2017); data were coded, and several categories were then generated. These included indications, contraindications, inclusion criteria, exclusion criteria, pre-cannulation considerations, peripheral cannulation considerations, post-cannulation considerations, complications, and patient outcomes. Categories were summarized via sub-categories and key considerations in a table (see Table 1 of Appendix A).

This literature review and environmental scan provided the evidence base for the creation of the nursing toolkit. It also serves as an updated summary of the current evidence for bedside ECMO cannulation.

Summary of the Consultations

After the literature review and environmental scan were conducted, consultations were undertaken with key collaborators in my workplace (see Appendix B). One physician and three nurses from various backgrounds and roles within the CCU were interviewed. Each had varying experiences with bedside ECMO cannulation in the CCU. A focus group was held with the three nurses, and a private interview was conducted with the physician. Interviews were audio-

recorded via the Voice Memos app on my iPhone. Recordings were permanently deleted after analysis. After all data were collected, I extracted quotations into tables, coded the data, and identified categories through inductive content analysis to describe the considerations and issues experienced during the peri-cannulation period in the CCU (Elo & Kyngäs, 2008; Kleinheksel et al., 2020; Meier, 2017). This method was chosen in order to describe the manifest content of interviews for translation into the content of the nursing toolkit (Elo & Kyngäs, 2008).

Results from the nursing focus group and physician interview were presented separately, as there were inconsistent themes across consultations. The physician interview data had a focus on the peri-cannulation process, whereas the nursing focus group data had a focus on nursing experiences (see Appendix B). For the nursing focus group, four categories were generated. Additionally, suggestions for the format and content of the nursing toolkit were gathered. The four categories were: a) Unclear Roles and Expectations, b) Clear Layout of Tasks/Information, c) Unfamiliar Territory, and d) Others as Experts. Under the category of Unclear Roles and Expectations, feelings of uncertainty about the responsibilities of CCU staff before and after OR staff arrived to cannulate were expressed. For Clear Layout of Tasks/Information, the nurses expressed a desire to have roles and expectations clarified in order to be able to participate in the care of their patients. In order to be prepared to assist with cannulation/caring for ECMO patients, all participants indicated a willingness to learn. In the third category, Unfamiliar Territory, nurses expressed limited knowledge of ECMO cannulation and its indications. The final category, Others as Experts, included data that evidenced an attitude that the CCU nurses were not and would never be experts in the peri-cannulation phase of ECMO; the OR team and cardiac surgeon were seen as the most knowledgeable and the leaders in ECMO cannulation. These categories are discussed in further detail in the consultation report (see Appendix B). The

suggested format for the nursing toolkit was a laminated booklet of checklists for the cannulation process and a visual presentation of key ECMO information to inform nursing care in the CCU.

From the physician's interview, six categories were generated. These were: a) Inclusion and Exclusion Criteria, b) Environmental Preparation, c) Cannulation, d) Post-Cannulation Considerations, e) ECPR Considerations, and f) Unit Culture and Expectations. These categories are briefly described below (see Appendix B for detailed descriptions). Inclusion and Exclusion Criteria detailed the criteria that the physician generally uses to decide patient candidacy for ECMO. This category also highlighted the unique and difficult decision the physician must make as to whether a patient is eligible for ECMO. Environmental Preparation included data that described the physician's expectations for preparing the patient and the environment for bedside cannulation. Cannulation included descriptions of the bedside cannulation process and expectations for CCU from the cannulating physician. Post-Cannulation Considerations and ECPR Considerations categorized data highlighting points of importance to prepare the patient for transfer post-cannulation and management of cardiac arrest in the peri-cannulation period, respectively. Finally, data containing descriptions of team dynamics and past experiences with bedside cannulation in CCU were grouped under Unit Culture and Expectations. The physician was also asked for suggestions on the nursing toolkit contents and format. The main suggestion given by the physician for the toolkit was adapting the current ECMO checklist provided to the CCU. They also offered to be involved in any capacity in the creation of a simulation or educational resource for nursing staff.

Overall, the response from all consultants regarding the creation of a nursing toolkit for bedside ECMO cannulation was positive. Further consultation was done after the booklet and PowerPoint presentation were completed. These were sent via email to the consultants for review

and feedback. All four participants approved the PowerPoint presentation and the checklists. One nurse and the physician offered suggestions for modifications to the checklists. These suggestions were further discussed and clarified over a Microsoft Teams meeting/via email. Suggestions were then used to modify the booklet as discussed.

Summary of the Resource Developed

After the consultations were completed, it was established that a quick-reference checklist for use at the bedside, in addition to a visual presentation with basic information about ECMO, would be the best resource for the CCU. Information gathered from the literature review, environmental scan, and consultations was used to create a bedside cannulation booklet, a PowerPoint presentation, and a corresponding video.

Checklists

An existing single-page ECMO preparation checklist was adapted into a 13-page booklet for quick bedside reference (see Appendix D). The first page of this booklet includes a colour-coded table of contents. Each colour corresponds to a phase of the ECMO process throughout the booklet for easy visual reference. These phases include the pre-cannulation phase, cannulation phase, post-cannulation phase, and ECPR. The second page summarizes the process through an ECMO cannulation roadmap.

The next section of the booklet includes five checklists for the pre-cannulation phase (orange). These checklists outline the delegation of roles and key preparatory actions to be completed before the cannulating team's arrival. Preparatory work is broken down into four checklists, specifying actions pertaining to the patient, required equipment, the environment, and medications/lines. Step-by-step instructions on how to order blood products, depending on

patient criteria, follow these checklists in the booklet. There are also two diagrams for quick reference of room setup and patient positioning.

The cannulation section is one page (green), outlining two scenarios and the corresponding expectations for CCU staff involvement. The first scenario is if the OR team is available to assist the cardiac surgeon with cannulation. The second scenario is if the OR team is unavailable, and the CCU nurses must assist with cannulation. For each event, role delegation and expected tasks to be completed are clearly outlined.

The post-cannulation section (blue) includes three checklists to complete after ECMO cannulation. These checklists are separated by category, namely assessment considerations, possible interventions, and transportation preparation.

Finally, an ECPR algorithm (purple) was developed to guide resuscitation efforts during cannulation. This algorithm was developed based on recommendations from the literature review/environmental scan and consultation with one of the cardiac surgeons at the SJRH. The algorithm is a single page that outlines key actions or considerations during each phase of the cannulation process that differ from the standardized advanced cardiovascular life support (ACLS) algorithm.

Visual Presentation

As suggested by the consultants, a visual presentation was created to provide bedside nurses with basic information about ECMO and the contents of the new bedside booklet (see Appendix E). The information about ECMO included a brief overview of what ECMO is, indications and contraindications, inclusion and exclusion criteria for use, patient outcomes, and possible complications. Additionally, indications/contraindications and inclusion/exclusion criteria for ECPR were reviewed. Finally, the bedside booklet and contents of the ECMO bin

stored on the nursing unit were described. A video of the presentation was recorded and has been made available to the resource nurse for dissemination, along with digital copies of the booklet and PowerPoint slides.

Discussion of Advanced Nursing Practice (ANP) Competencies

Through this project, I have demonstrated five of the advanced nursing practice (ANP) competencies outlined in the ANP framework set forth by the Canadian Nurses Association (CNA, 2019). These are research utilization, leadership, consultation and collaboration, education, and direct comprehensive care.

I demonstrated the competency of research utilization through this practicum project. Evidence-based literature was used to inform the development of the toolkit. From planning to developing the toolkit, research was at the centre. I demonstrated my ability to identify issues in need of evidence-based resources to support patient care and nursing practice. Through an integrative literature review, environmental scan, and consultations, the use of multiple methods of research was demonstrated. As part of the integrative review and environmental scan, I conducted a critical appraisal of the included articles. After completing this review, I prepared a manuscript with my advisor to submit for publication, thus supporting ongoing research that impacts nursing practice and clinical practice guidelines.

I enacted the Leadership and Consultation/Collaboration competencies by serving as a proactive agent of change within my workplace. After recognizing a systemic deficit in nursing resources and knowledge, I initiated a quality improvement strategy that bridged the gap between current practice and evidence-based standards. This process required intra- and interprofessional consultation, where I synthesized input from diverse collaborators to ensure the toolkit was both clinically relevant and sustainable. By engaging team members in the problem-solving process, I

fostered a culture of collaborative practice, effectively transitioning from an individual contributor to a facilitator of collective clinical excellence. My leadership in this project ensures that the resulting resource is not merely a document, but an effective knowledge translation tool for standardized, high-quality patient care.

Educational competencies were met through identifying the learning needs of staff and developing an appropriate resource to address these. The toolkit created from this project will "contribute to the knowledge, clinical skills and client care abilities of team members and other health-care providers" (CNA, 2019, p. 32) through knowledge-sharing. Furthermore, through this project, I planned and initiated an educational resource based on the needs of the nursing unit.

Similarly, direct comprehensive care competencies were met through the dissemination of knowledge "using appropriate delivery methods" (p. 30). Furthermore, I provided a channel for the appropriate dissemination of knowledge through the creation of an education toolkit. This, in turn, will potentially "minimize variances in care and prevent adverse outcomes" (CNA, 2019, p. 30) by preparing nursing staff to care for complex patients. Finally, through collaboration with the CCU resource nurse, a possible plan to measure outcomes of the toolkit was created.

Next Steps

The next steps for this project include final approvals, dissemination, and evaluation of the project's effectiveness in clinical practice. Final approval from the CCU resource nurse and the head cardiovascular surgeon (main ECMO specialist) was obtained. Further official sign-offs from the department head may be required to make this checklist a standing order (i.e., for bloodwork orders and blood product administration), as requested by the same. This was

discussed with the cardiovascular surgeon and the resource nurse for further inquiry after this project was completed.

For dissemination, a copy of the bedside booklet, PowerPoint presentation, and video of the presentation have been provided to the resource nurse. Recommendations for the method of dissemination have been discussed with the CCU resource nurse. The PowerPoint slides and video will likely be posted to the nursing unit's Microsoft Teams page, where all clinical resources are accessed. I also recommended that the checklists be printed, laminated, and placed in a binder. A whiteboard marker should be kept with the binder to use to check off tasks as they are completed. The binder allows for pages to be removed if multiple staff need access to instructions at the same time (e.g., prepping the patient and ordering blood products). This binder will be kept with the OR-style table and ECMO bin that are currently stored on the nursing unit. Additionally, I have recommended that the checklist be disseminated to all cardiac surgeons and CCU attending physicians who are involved in bedside ECMO cannulation for awareness of the expectations for CCU, allowing all care team members to be aware of team expectations.

In addition to disseminating the content, there is a need to evaluate the effectiveness of the toolkit in improving nursing knowledge, team dynamics, and clinical practice. The resource nurse who will be disseminating the project in the clinical setting reported that a simulation team from the provincial health network is interested in conducting a simulation of an ECMO cannulation based on the checklist created for this toolkit. After this simulation, feedback can be collected from the participating staff for improvements to the checklist. A survey of staff members could be taken before and after the simulation to evaluate the effectiveness of the checklist. Additionally, a survey could be collected before and after the video presentation are

viewed by staff to evaluate nurses' familiarity, comfort, and knowledge of bedside ECMO cannulation.

The information gathered from the literature review and environmental scan will also be included in an article that is to be submitted for publication. In collaboration with my advisor, I have prepared a manuscript to be submitted to a few selected journals. This will be another avenue of dissemination of the information gathered and analyzed during this project to contribute to the growing body of evidence on bedside ECMO cannulation and ECPR. Additionally, the simulation team from the health network expressed interest in co-authoring an article after a simulation is conducted to evaluate the effectiveness of the booklet.

Conclusion

After identifying a gap in nursing knowledge and the availability of clinical resources pertaining to bedside ECMO cannulation, I chose to focus my project on creating a resource to fill this gap. Specifically, the focus of this project was to provide an evidence-based toolkit to support nurses caring for patients requiring ECMO cannulation in a CCU setting. Through the conduction of a literature review, environmental scan, and workplace consultations, I was able to gather information to use as a base for a bedside ECMO toolkit for nurses. This included a bedside reference booklet with step-by-step instructions to prepare for and assist with cannulation, post-cannulation tasks before transfer off the unit, and management of a patient in cardiac arrest during cannulation. Next steps for this project include the dissemination and evaluation of the usefulness of the toolkit. By completing this project, I have demonstrated multiple advanced nursing practice competencies. I hope that this project will help to close the identified nursing knowledge gap and engender confidence in nursing staff while caring for patients in the peri-cannulation period of ECMO.

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Appendix A

Literature Review and Environmental Scan

Bedside Extracorporeal Membrane Oxygenation Cannulation and ECPR: An Integrative Review and Environmental Scan

Veno-arterial extracorporeal membrane oxygenation (VA-ECMO) and extracorporeal cardiopulmonary resuscitation (ECPR) are not new concepts in the literature, nor in clinical practice. VA-ECMO is used in a multitude of conditions as a bridge to recovery or as a precursor to another intervention in critically ill patients, including in cardiopulmonary resuscitation, i.e., ECPR (Chaves et al., 2019; Kanchi et al., 2022; Napp et al., 2016). This method of cardiopulmonary bypass facilitates improved blood flow through the body and adequate oxygenation and removal of carbon dioxide from the blood (Horizon Health Network [HHN], 2025). Blood is drawn into the ECMO circuit from the venous system, run through the centrifugal pump, oxygenator, and heat exchanger, and returned to the arterial system at a designated flow rate (HHN, 2025).

While these are not new concepts, a nursing knowledge gap was identified within my workplace in the coronary care unit at the Saint John Regional Hospital (SJRH) in Saint John, New Brunswick. After determining the need for a nursing resource about bedside VA-ECMO cannulation through informal consultations, a literature review and environmental scan were conducted to develop a knowledge base on which the resource would be created. In order to gain a broader perspective for creating the resource and clinical practice protocol, an integrative review and environmental scan were combined. This concurrent approach allowed for the simultaneous synthesis of empirical evidence and current clinical protocols. By running these searches side-by-side, the project ensured that the resulting knowledge base reflected both the

most recent scientific literature and the real-time state of environmental readiness. Content explored includes indications and contraindications, as well as inclusion and exclusion criteria. It also covers the three phases of ECMO cannulation at the bedside (i.e., pre-cannulation, cannulation, and post-cannulation), outcomes of VA-ECMO, and associated complications. Since patients on VA-ECMO are transferred to another nursing unit at Saint John Regional Hospital, the focus of this review is on the bedside cannulation process, rather than the long-term management of the patient and ECMO circuit. The overall goal of this literature review and environmental scan is to inform the development of a toolkit to be used by critical care registered nurses to guide practice regarding the initiation of extracorporeal membrane oxygenation (ECMO) at the bedside.

Methodology

Literature Search and Environmental Scan Strategy

For the literature review, six databases were searched (i.e., Embase, PubMed, Google Scholar, CINAHL, Cochrane, and Ovid MEDLINE). Search terms used included combinations of nurs*; ECMO or extracorporeal membrane oxygenation; ECLS or extracorporeal life support; bedside cannulation; catheterization; insert; cannula*; placement*; emerg* or ED; operating room or OR; intensive care unit or ICU; and patients' rooms. A librarian, in addition to my academic advisor, was consulted for assistance with search strategies.

The environmental scan included emailing 17 contacts from 8 ECMO centres across Canada (i.e., Foothills Medical Centre, Mazankowski Heart Institute, Halifax Infirmary - Queen Elizabeth II Health Sciences Centre, St. Boniface Hospital, Toronto General Hospital, Jewish General Hospital, Vancouver General Hospital, Saint John Regional Hospital). These hospitals were chosen as the ECMO nurse educator at the SJRH had contact information for liaisons at these locations.

Search Outcomes and Screening

After reviewing titles and abstracts from the results, 79 articles were included for full-text review; 31 articles were selected for the final review. Of the eight hospitals contacted, three provided ECMO education resources (Department of Critical Care Medicine Calgary [DCCMC], 2024; HHN, 2025; Vancouver Coastal Health [VCH], 2020). There was no response from five contacts, and eight contacts responded that they did not currently have a resource developed for informing nursing practice in bedside ECMO cannulation.

Inclusion and Exclusion Criteria

Search limits for the literature review included articles within the last 10 years (January 2015 to September 2025), available in English, review articles only, and full-text articles. No restrictions were placed on the country of origin. For the final review, selected articles comprised those with a focus on the adult population, the peri-cannulation period, and VA-ECMO/ECPR (as opposed to veno-venous ECMO). All three resources obtained from institutions were included in the environmental scan.

Data Extraction

Articles (narrative reviews and guidelines) and education resources were reviewed. Data was directly extracted with quotes to three extraction sheets. Narrative reviews, guidelines, and educational resources were grouped into separate sheets. These included sections for the title, authors, year, and country or institution of origin, the purpose of the review, methods (design, number of studies, databases searched, data extraction, data analysis, and data synthesis) as applicable, key findings, critical appraisal, content (direct quotations), and coding/categories. Each sheet included different headings as appropriate to the content and type of design (e.g., educational resources and practice guidelines did not include critical appraisal). Article

information and key findings were then summarized in literature summary tables (see Table 1, Table 2, and Table 3 in Appendix).

Data Analysis and Synthesis

Content analysis was used for the data analysis and synthesis. Categories were identified from the data extracted. These included inclusion criteria, exclusion criteria, indications, contraindications, pre-cannulation considerations, cannulation considerations, post-cannulation considerations, ECPR, outcomes, and complications. The categories were used to group data and subsequently code and organize sub-categories across articles/resources. These are presented in the results section of this paper.

Review articles were critically appraised using the Public Health Agency of Canada (PHAC, 2014) and the Critical Appraisal Skills Programme's (CASP, 2024) critical appraisal toolkits (see Table 1 in Appendix). Of the 20 review articles, all were rated as low quality, except for two (Chaves et al., 2019; Condella et al., 2025), which received a medium quality rating. All were narrative reviews, with most providing poor reports on the methodologies used.

In addition to these reviews, a total of 11 clinical practice guidelines documents and 3 clinical practice resources were analyzed. Several reviews/guidelines noted the limited amount of strong evidence (i.e., the majority of studies were observational, and there were few randomized controlled studies) to support recommendations. Some guidelines were based on expert consensus in addition to a literature review. Finally, key findings were integrated and summarized in this paper based on identified themes to create a practice protocol for bedside VA-ECMO cannulation.

Results and Implications for Practice Guidelines

In this section, the combined results from the literature review and environmental scan are presented. Each theme identified is discussed as part of a clinical practice protocol. Refer to Table 1 for a summary of key findings for each theme.

Table 1

Summary of Key Findings

CATEGORY	SUB-CATEGORIES/KEY CONSIDERATIONS
INDICATIONS	- Cardiac arrest - Cardiogenic shock - Respiratory failure - Severe thoracic trauma - Sepsis - Anaphylactic shock - Refractory thyroid storm - ANCA-associated vasculitis - Obstructive shock - Failure to wean from cardiopulmonary bypass - Post-op graft failure
CONTRAINDICATIONS	- End-stage organ failure/disease or multi-system organ failure with no option for transplant - Uncontrolled hemorrhage - Contraindication to anticoagulation - Advanced age (>75 years) - Untreated aortic dissection - Aortic valve insufficiency/regurgitation - Poor prognosis despite ECLS (e.g., prognostic scores; life expectancy < 1 year) - Metastatic malignancy - Severe neurological disease or injury with poor prognosis - Morbid obesity - Frail - Outside of patient's goals of care - High-setting mechanical ventilation for > 7 days - Inadequate vascular access - Inability to receive blood products
INCLUSION CRITERIA (GENERAL ECLS)	- < 75 years of age - Absence of comorbidities

CATEGORY	SUB-CATEGORIES/KEY CONSIDERATIONS
	- Timing to ECLS < 6 hours from identification of CS, within 60 minutes of identifying refractory shock
INCLUSION CRITERIA (ECPR-SPECIFIC)	- Exhibiting signs of life during CPR - Initial shockable rhythm of PEA - Witnessed arrest with bystander CPR - Temporary ROSC - Higher baseline pH/ lower baseline lactate - $ETCO_2 \geq 10$ mmHg during CPR - PaO_2 levels - Timing in ECPR < 5 minutes of no-flow time, < 60 minutes of low-flow time
EXCLUSION CRITERIA (GENERAL ECLS)	- > 75 years of age - Frail - Severely impaired baseline status - Presence of life-limiting conditions - Not within patient's goals of care - Presence of comorbidities - Severe trauma - Active and uncontrolled hemorrhage - Aortic dissection - Aortic valve incompetence - Tension pneumothorax - Severe pleural effusion - Cardiac tamponade - Papillary muscle rupture - Interventricular septal rupture - Free wall rupture - Significant atheroma or calcification
EXCLUSION CRITERIA (ECPR-SPECIFIC)	- Non-shockable initial rhythm - Persistent signs of insufficient tissue perfusion (i.e., lactate ≥ 20 mmol/L, pH < 6.8, $ETCO_2$ < 10 mmHg) - Unwitnessed arrest - Prolonged no-flow and low-flow (> 60 minutes) times

CATEGORY	SUB-CATEGORIES/KEY CONSIDERATIONS
PRE-CANNULATION CONSIDERATIONS	- Identify next of kin - Exit strategy identified - Bedside TEE or TTE and POCUS - Bloodwork (any need for correction pre-cannulation?) - Adequate IV and arterial access - Site preparation - Discontinuing tube feeds +/- insulin gtts, evacuating stomach - Holding heparin gtt and other anticoagulants as per MD - Blood products and fluids available with lines primed - Heparin bolus ready - Clearing room and positioning patient - All necessary equipment and supplies available and positioned in room - ECMO machine primed - PPE for staff - Medications (IV push and gtts) ready; ACLS cart available - All appropriate staff aware and present - Crowd control - Delegation of roles/ pre-briefing
PERIPHERAL CANNULATION CONSIDERATIONS (GENERAL ECLS)	- Technique to be used (Seldinger, modified Seldinger, surgical cut-down, hybrid approach) - Contralateral versus ipsilateral - Use of Dacron graft, end-to-side anastomosis of a prosthesis - Imaging guidance (POCUS, TEE, TTE, fluoroscopy) - Confirming wire placement prior to dilation - Determining cannula size and length (patient weight and sex, vessel size) - Placement of distal perfusion cannula - Use of central lines already in groin to aid in cannulation - Heparin bolus on placement of guidewires - Use of stiff guidewires (risks and indications) - Backflushing or use of heparinized saline to prevent clotting of first cannula on placement - Clamping cannulas after obturator and wire removed - Underwater seal connection - Ongoing monitoring of vital signs, sedation, pain management

CATEGORY	SUB-CATEGORIES/KEY CONSIDERATIONS
PERIPHERAL CANNULATION CONSIDERATIONS (ECPR-SPECIFIC)	- Use of mechanical CPR - Limiting defibrillation and rhythm checks - No epinephrine toward end of cannulation - Monitoring changes in $ETCO_2$ every 2 minutes - Continuing compression for 1-minute post-cannulation (or until goal-flow reached)
POST-CANNULATION CONSIDERATIONS	- Monitoring and assessment - Medication management - Transportation - Post-ECPR care - Staff debriefing - Documentation - Patient positioning - Terminating ECMO/end-of-life care
COMPLICATIONS	- Thromboembolic events - Hemorrhagic events - Major vessel dissection or perforation - Pseudoaneurysm formation - Nerve damage - Transfixation of the inguinal ligament - Accidental decannulation - Cannula migration - Limb ischemia - Hypoperfusion with multi-system organ failure - Systemic or localized infections - Thoracic trauma - Neurological injury - Differential hypoxemia - LV distension - Prevention and management considerations
OUTCOMES	- Limited strong evidence on benefits of ECMO - May improve survival and functional outcomes for some conditions - Survival rate widely variable across conditions; overall, 41% survival rate in ELSO data registry (global)

Note. ACLS = advanced cardiovascular life support; CPR = cardiopulmonary resuscitation; CS = cardiogenic shock; ECLS = extracorporeal life support; ECMO = extracorporeal membrane oxygenation; ECPR = extracorporeal cardiopulmonary resuscitation; ELSO = extracorporeal life

support organization; $ETCO_2$ = end-tidal carbon dioxide; LV = left ventricle; PaO_2 = partial pressure of oxygen; PEA = pulseless electrical activity; POCUS = point-of-care ultrasound; PPE = personal protective equipment; ROSC = return of spontaneous circulation; TEE = transesophageal echocardiogram; TTE = transthoracic echocardiogram

Indications

There are several indications for VA-ECMO discussed in the literature; 16 of the articles/resources included in this review discussed indications for VA-ECMO (Badulak & Shinar, 2020; Bernhardt et al., 2022; Chaves et al., 2019; Condella et al., 2025; DCCMC, 2024; Eckman et al., 2019; Extracorporeal Life Support Organization [ELSO], 2017; HHN, 2025; Kanchi et al., 2022; Karaoğlanoğlu & Akgün, 2023; Keebler et al., 2018; Lorusso et al., 2021; Napp et al., 2016; Perman et al., 2024; Swol et al., 2016; Swol et al., 2018). The first major indication is in the context of cardiogenic shock. This can be due to a multitude of etiologies, including acute myocardial infarction, pulmonary embolism, myocarditis, pharmacologic overdose, acute exacerbation of chronic heart failure, cardiomyopathy, and electrolyte imbalances. Normally, VA-ECMO is only considered in cardiac failure if the etiology is reversible or there is an option for an organ transplant. VA-ECMO can also be used in cardiopulmonary failure, as it allows for bypass of gas exchange and generates blood flow.

The second major indication identified in the literature is refractory cardiac arrest with a presumed or known reversible etiology. This method of VA-ECMO is known as extracorporeal cardiopulmonary resuscitation (ECPR). It establishes adequate blood flow and oxygenation to prevent ischemic damage from poor perfusion in mechanical or manual CPR. When ECPR is initiated, it allows clinicians time to determine the cause of the arrest, if not already known, and to treat it.

In addition to primarily cardiac conditions, there are several other conditions in which VA-ECMO is indicated. For example, studies have discussed its use in hypoxemic respiratory failure, severe thoracic trauma, sepsis, anaphylaxis, refractory thyroid storm, severe asthmaticus, ANCA-associated vasculitis, and obstructive shock. It has also been used in patients who fail to wean from cardiopulmonary bypass in the OR and post-op graft failure. VA-ECMO is typically used as a bridging therapy (i.e., bridge to a ventricular assist device, to transplant, to a decision, or to recovery); this invasive therapy is neither a long-term solution nor a stand-alone treatment.

Contraindications

When clinicians consider VA-ECMO or ECPR, it is essential to assess whether a patient's condition constitutes a contraindication to these invasive therapies. Twelve articles/resources listed contraindications for VA-ECMO and/or ECPR (Badulak & Shinar, 2020; Chaves et al., 2019; Douflé et al., 2024; Eckman et al., 2019; ELSO, 2017; HHN, 2025; Kanchi et al., 2022; Karaoğlanoğlu & Akgün, 2023; Keebler et al., 2018; Napp et al., 2016; Swol et al., 2018; Tsangaris et al., 2021). Some contraindications were listed as absolute, while others were listed as relative. There was an unclear consensus noted between some articles over whether certain contraindications were absolute or relative, e.g., end-stage liver disease, multi-system organ failure, known brain injury, uncontrolled bleeding or contraindication to anticoagulation, advanced age, untreated aortic dissection, aortic valve insufficiency/regurgitation, suppressed immunity, and acute intracranial hemorrhage. The use of prognostic scores, such as the modified SAVE or PREDICT VA-ECMO scores, can help clinicians make informed decisions about the risk-benefit of initiating VA-ECMO or ECPR. Contraindications primarily include any conditions that are likely to prevent the patient from achieving a functional recovery or cause significant complications, thereby outweighing any potential benefits of ECLS. Since many

conditions are subject to debate among clinicians as to whether they are absolute contraindications, it is recommended that consideration for ECLS be taken on a case-by-case basis.

A major contraindication highlighted in the literature is the presence of irrecoverable conditions, despite the initiation of VA-ECMO or ECPR. These include metastatic malignancy, end-stage organ failure without option for transplant, severe neurological disease with poor prognosis (e.g., dementia), severe irreversible brain injury (e.g., massive stroke), or life expectancy < 1 year. Other contraindications include morbid obesity, mechanical ventilation for longer than 7 days on high support settings, an inability to receive blood products, inadequate vascular access (in peripheral cannulation for ECLS or ECPR), frailty, or ECLS not within the patient's goals of care.

Inclusion and Exclusion Criteria for Evaluating Patients for ECLS

In addition to indications and contraindications, various inclusion and exclusion criteria should be considered when evaluating patients for ECLS. Each institution is recommended to create its own list of inclusion and exclusion criteria, as there is wide variability in suggested criteria in the literature and between institutions or clinicians (Brandorff et al., 2023; Condella et al., 2025; Olson et al., 2022; Richardson et al., 2021).

Inclusion Criteria

Of the 34 articles, guidelines, and clinical practice documents reviewed, 21 discussed possible inclusion criteria (Abrams et al., 2022; Ali et al., 2024; Badulak & Shinar, 2020; Bartos & Yannopoulos, 2020; Bernhardt et al., 2022; Brandorff et al., 2023; Cassara et al., 2022; Ciullo & Tonna, 2024; Condella et al., 2025; Kanchi et al., 2022; Karaoğlanoğlu & Akgün, 2023; Keebler et al., 2018; Kiss et al., 2025; Lorusso et al., 2021; Oliver et al., 2024; Olson et al., 2022;

Richardson et al., 2021; Rollo et al., 2019; Swol et al., 2016; Tsangaris et al., 2021; VCH, 2020). Inclusion criteria were selected based on limited/ weak evidence of factors associated with improved outcomes. Age of the patient was a major factor noted in the literature; however, there was no clear consensus on the cut-off age (range from 60 to 75 years). Other factors included the likelihood of survival with a functional outcome, ECLS within the patient's goals of care, presence of a reversible cause of arrest or condition, and absence of major comorbidities (e.g., end-stage organ failure, terminal illness, futile conditions, and greater than mild aortic incompetence). ECPR-specific inclusion criteria included exhibiting signs of life during CPR, initial shockable rhythm or PEA, witnessed arrest with bystander CPR, temporary ROSC achieved, higher baseline pH/lower baseline lactate, $ETCO_2 \geq 10$ mmHg during CPR, and PaO_2 levels. In addition to these factors, some reviews recommended the use of ECMO or ECPR prediction score tools to assist clinicians with eligibility decision-making (e.g., RESCUE-ICHA, RESP, Murray score, SAVE, REMEMBER, ENCOURAGE, CARDshock).

Timing was another important factor highlighted in the decision-making process. In the management of cardiogenic shock, it is recommended that ECLS be initiated within 6 hours of initial identification of shock, and within 60 minutes of recognizing shock as refractory to conventional pharmacotherapy and fluids; however, recommendations for timing in cardiogenic shock are noted to lack a strong evidence base. For ECPR, it is recommended that ECLS not be initiated prior to determining that cardiac arrest is refractory (10–20 minutes). ECPR is advised in patients with no-flow times of < 5 minutes. Total no-flow and low-flow times (i.e., CPR) should be limited to < 60 minutes before ECLS initiation. In the context of ECPR, there may be limited information and time to make a decision; therefore, it has been noted in multiple articles

that it may be appropriate to consider ECPR to allow time for further information to be obtained (i.e., to find the cause of cardiac arrest and treat).

Exclusion Criteria

Exclusion criteria included many of the previously identified contraindications. Eleven articles/resources offered recommendations for exclusion criteria (Abrams et al., 2022; Ali et al., 2024; Bartos & Yannopoulos, 2020; Bernhardt et al., 2022; Brandorff et al., 2023; Douflé et al., 2024; Karaoğlanoğlu & Akgün, 2023; Richardson et al., 2021; Rollo et al., 2019; Rollo et al., 2019; VCH, 2020). As previously stated, if ECLS is not within the patient's goals of care, they should be excluded from receiving ECMO or ECPR. Older age (> 75 years), frailty, severely impaired baseline functional status, life-limiting conditions, and the presence of comorbidities have all been recommended as exclusion criteria. Additionally, severe trauma, active and uncontrolled hemorrhage, aortic dissection, aortic valve incompetence, tension pneumothorax, severe pleural effusion, cardiac tamponade, papillary muscle rupture, interventricular septal rupture, free wall rupture, and significant atheroma or calcification are to be considered exclusion criteria when evaluating patient eligibility. In the context of ECPR, patients may be excluded in instances of non-shockable initial rhythms, persistent signs of insufficient tissue perfusion (e.g., lactate ≥ 20 mmol/L, pH < 6.8, $ETCO_2$ < 10 mmHg), unwitnessed arrest, and prolonged no-flow and low-flow times (i.e., > 45 to 90 minutes).

Pre-Cannulation Phase

Several considerations are involved in the pre-cannulation phase of bedside ECMO cannulation. A total of 17 articles and resources discussed these pre-cannulation considerations (Abrams et al., 2022; Badulak & Shinar, 2020; Brandorff et al., 2023; Cassara et al., 2022; Chaves et al., 2019; Condella et al., 2025; DCCMC, 2024; Douflé et al., 2024; Gajkowski et al.,

2022; HHN, 2025; Keebler et al., 2018; Kiss et al., 2025; Lorusso et al., 2021; Oliver et al., 2024; Richardson et al., 2021; Swol et al., 2016; VCH, 2020). If time permits and if it is not already known, the next of kin should be identified, and the patient's wishes ascertained. A next of kin will often need to be involved in decision-making pre- and post-cannulation, as many patients are incapacitated and unable to be involved. An exit strategy should also be at the forefront of the decision to cannulate.

Appropriate patient pre-assessment and preparation are also important to consider in the pre-cannulation phase. If time permits, a bedside transthoracic echocardiogram (TTE) or transesophageal echocardiogram (TEE) and bedside ultrasound should be performed to assess for contraindications, reversible causes of arrest, cardiac function, peripheral ECMO access sites, and to rule out thrombi. An echocardiogram may not be possible in cardiac arrest; however, it has been noted in some reviews that a TEE may be possible during ECPR. Other assessments include blood panels, such as cross-matching for blood products, complete blood count, electrolytes, extended electrolytes, ionized calcium, lactate, and coagulation studies. Some institutions may recommend correcting abnormal lab values (e.g., Hgb < 80 g/L, PLT < 80 x 10^9/L) if time permits. Patients should also have adequate intravenous (IV) and arterial access in preparation for ECLS initiation. At least two peripheral IV sites or a central venous line (preferably in the left internal jugular) are recommended, in addition to a right radial arterial line. If not already placed, arterial and central venous lines may be placed before, during, or after, depending on the urgency of ECLS initiation. If no invasive arterial line is present, a non-invasive blood pressure may be cycled every 1 minute during the procedure. Peripheral cannulation sites should be prepared by shaving the bilateral groins, removing hair debris, and disinfecting with Betadine. If a tube feed and an insulin drip (if applicable) are running, these

should be stopped, and stomach contents emptied. If a heparin drip is running, it should be stopped, as per the cannulating physician or intensivist. Just before cannulation, the patient is to be draped.

The availability of appropriate resources and the proper setup of the room are essential considerations before starting ECLS cannulation. Blood products should be readily available, i.e., 2 to 4 units of packed red blood cells, and 500 ml of 5% albumin. Advanced cardiovascular life support (ACLS) medications, vasopressor/inotrope drips (such as epinephrine or norepinephrine), phenylephrine, paralytics, analgesics, and sedation should all be considered, prepared, and ready for use. Fluid and blood administration lines should be primed and attached to the patient. The ECMO circuit may be primed with crystalloid for adult patients; however, this may cause a dilutional effect once ECLS is initiated. 5,000 to 10,000 units of heparin (or 50–100 units/kg) should be prepared and ready for administration as a bolus during cannulation. The room should be cleared of unnecessary equipment and personnel. The bed should be pulled into the centre of the room with the patient centred and supine on the bed, side rails down, and the bed at waist height. Adequate lighting should be available. Equipment needed for the procedure (OR table or 2–3 bedside tables, ultrasound, TEE, ECMO machine, LUCAS for mechanical CPR, ACLS cart, cannulation supplies) should be available and appropriately positioned in the room. Any necessary personal protective equipment should also be available for staff to use.

Finally, human resources should be considered in the pre-cannulation phase. All necessary staff should be notified, including anesthesia, perfusion, and respiratory. If time permits, a pre-briefing may be beneficial, as well as the assignment of clear roles. During ECPR, two separate teams are needed – one for running the code and the other for cannulating. A staff

member should be designated for crowd control to prevent unnecessary personnel from overcrowding the room.

Cannulation Phase

Twenty-six articles/resources reviewed considerations during the cannulation phase (Ali et al., 2024; Badulak & Shinar, 2020; Bartos & Yannopoulos, 2020; Bernhardt et al., 2022; Brandorff et al., 2023; Cassara et al., 2022; Chaves et al., 2019; Condella et al., 2025; DCCMC, 2024; Douflé et al., 2024; Eckman et al., 2019; ELSO, 2017; Gajkowski et al., 2022; HHN, 2025; Kanchi et al., 2022; Kiss et al., 2025; Lorusso et al., 2021; Nanjayya & Murphy (2015a); Nanjayya & Murphy (2015b); Napp et al., 2016; Oliver et al., 2024; Richardson et al., 2021; Swol et al., 2016; Swol et al., 2018; Tsangaris et al., 2021; VCH, 2020). Topics included location and cannulation technique, monitoring considerations, supplies, special considerations in ECPR, and connecting the circuit.

VA-ECMO can be initiated centrally via thoracotomy or sternotomy, or peripherally. Central cannulation is beyond the scope of this review, as central cannulation is not performed initially at the bedside. Peripheral cannulation can be achieved through the femoral, axillary, or neck vessels. Although, subclavian or axillary access is usually used as a last resort. The femoral site is favoured in cardiogenic shock or ECPR. It is recommended that a contralateral approach be taken, if possible, to reduce the risk of limb ischemia and arteriovenous fistula formation. In this configuration, the venous cannula should be in the right groin as it is a direct path to the inferior vena cava and right atrium for ease of placement. There are different approaches to cannulating via the femoral vessels, including the Seldinger technique, modified Seldinger technique, surgical cut-down, and hybrid approaches. The Seldinger technique (i.e., serial dilations) is recommended over surgical cut-down in ECPR; however, cut-down may be

indicated in a prolonged arrest. Surgical cut-down may also be indicated in cases of complex or failed percutaneous (i.e., Seldinger technique) insertion. A Dacron graft or end-to-side anastomosis of a prosthesis may be used to prevent limb ischemia, but is not recommended in ECPR. Bedside point-of-care ultrasound (POCUS), TTE, TEE, or fluoroscopy (most ideal) is recommended in peripheral cannulation to guide cannulation of vessels, advancement of wires and cannulas, and guide CPR quality (TEE). Wire position should be confirmed prior to dilation if using the Seldinger technique with ultrasound, x-ray, or fluoroscopy. It is important to note that patient positioning and ventilation settings can affect final cannula positioning.

Cannula sizes should be determined based on patient weight, vessel size, and patient sex, with a balance between achieving optimal ECMO flow and minimizing the risk of limb ischemia, left ventricular (LV) distension, blood stasis, and pulmonary edema. Recommended cannula sizes vary significantly, ranging from 17–29 Fr for the venous cannula and 15–25 Fr for the arterial cannula. It has been noted that the risk for limb ischemia is higher with larger cannulas (> 20 Fr) in women, younger patients, and those with peripheral artery disease. Cannula lengths vary from 50–70 cm for venous access and 20–40 cm for arterial access. Cannulas are internally reinforced with wire or plastic, although wire is preferred as it is more durable. During cannulation, or within 4–6 hours of cannulation, it is recommended that a distal perfusion catheter (4–9 Fr) be placed in the same leg as arterial cannulation to reduce the risk of limb ischemia. If central access lines are already in place in the groin, these may be used to thread guidewires into vessels for cannulation. Typically, 150 cm guidewires are used for venous access and a minimum of 100 cm guidewires for arterial access. Swol et al. (2016) caution against using stiff guidewires in the absence of fluoroscopic imaging; however, stiff guidewires may be

essential in conditions such as peripheral vascular disease, obesity, and in patients with difficult anatomy.

On cannulation (usually at the time of placement of guidewires), an intravenous heparin bolus of 5,000 units, or 50–100 units/kg, is administered. Once the first cannula is placed, it should be flushed with heparinized saline or backflushed to prevent clotting while the second cannula is placed. Cannulas may be clamped once the internal obturator and guidewire are removed. Connection of cannulas is performed using an underwater seal (i.e., crystalloid poured over the connection site continuously) to ensure no air bubbles enter the circuit. Before flow is initiated, the line and pre-primed circuit should be checked for air bubbles.

Supportive therapies and monitoring should be continued throughout the cannulation process, including titration of inotropes, vasopressors, fluids, sedatives, analgesics, and paralytics as prescribed by the physician. Mean arterial pressure goals and status should be communicated with the cannulating team. Should hypotension occur on initiation of ECLS, calcium chloride with or without bicarbonate may be prescribed. Appropriate sedation (deep, with muscle relaxation) is also vital, especially for direct cut-down to prevent air embolism formation (i.e., preventing spontaneous breathing).

In instances of cardiac arrest, it is recommended that mechanical CPR (e.g., with LUCAS) be used to limit the number of staff in the room and maintain adequate compressions. This recommendation, however, has been noted to be based not on evidence but on expert opinion. Many reviews suggest no defibrillation once cannulation has begun to avoid endangering staff and limiting pauses in compressions for rhythm checks. Instead, the code team should monitor for rises in $ETCO_2$ levels every 2 minutes. Once adequate flow from the ECMO machine has been achieved ($\geq$ 3 LPM, or around one-minute post-flow initiation), compressions

may be stopped. If a lethal, shockable rhythm persists, defibrillation is advised. In addition to limiting rhythm checks and defibrillation, limiting administration of epinephrine boluses toward the end of cannulation is suggested to avoid hypertension once ECLS is initiated.

Post-Cannulation Phase

Twenty-four articles/resources discussed post-cannulation considerations (Badulak & Shinar, 2020; Bartos & Yannopoulos, 2020; Brandorff et al., 2023; Cassara et al., 2022; Chaves et al., 2019; Ciullo & Tonna, 2024; Condella et al., 2025; DCCMC, 2024; ELSO, 2017; Gajkowski et al., 2022; HHN, 2025; Keebler et al., 2018; Kiss et al., 2025; Labib et al., 2022; Lorusso et al., 2021; Nanjayya & Murphy (2015a); Nanjayya & Murphy (2015b); Napp et al., 2016; Oliver et al., 2024; Richardson et al., 2021; Swol et al., 2016; Swol et al., 2018; Tsangaris et al., 2021; VCH, 2020). Some considerations are for several hours or days after cannulation and were not included as they are beyond the scope of this review.

Monitoring and Assessment

Ongoing monitoring and assessment are a major part of the immediate post-cannulation period. If not already placed, an arterial line should be placed, as blood flow may be non-pulsatile. A Doppler and manual blood pressure cuff may be used until placement of an arterial line is completed. It is advised that the arterial line be placed in the right radial artery, as this site will allow for monitoring for differential hypoxemia (see 'Complications' section). Consideration should also be given to the insertion of a pulmonary artery catheter (Swan-Ganz catheter) for monitoring LV filling pressures and central venous pressure. Other monitoring parameters include blood panels (if not already completed), mixed venous blood gas to monitor perfusion if MAP is low (goal $SvO_2 > 70\%$), lower limb oxygenation monitoring (e.g., with HemoSphere), continuous ECG monitoring, and arterial pulsatility (as an indicator of cardiac contractility). No

optimal MAP has been identified according to the ELSO; however, several reviews have provided recommendations ranging from 50 to 83 mmHg. A high MAP (> 80 mmHg) is discouraged in the literature, citing an increased risk of LV distension.

There is no clear consensus on ventilator setting recommendations within the literature, and they are usually based on pathology. If lung injury or concurrent respiratory failure is present, rest settings are recommended (e.g., PEEP 5–15 cmH_2O, low respiratory rate around 10 breaths per minute, FiO_2 < 30–60%, plateau inspiratory pressure < 25 cmH_2O). Settings should be titrated based on arterial blood gas results to avoid hypocarbia and hyperoxia. If no lung injury is present, more typical ventilator settings may be used at the discretion of the respiratory therapist or attending physician. SPO_2 monitoring should be monitored on the right upper limb or forehead; the goal oxygen saturation is usually 90% or above. Arterial blood gases should be collected from the right radial arterial line, with a target PaO_2 of 92-97% and a SaO_2 of > 95%.

Imaging is another important assessment factor discussed by several authors. Cannula positioning should be confirmed via x-ray, radioscopy, fluoroscopy, or echocardiography. A POCUS can be used to assess for complications (e.g., pneumothorax, thoracic/abdominal bleeding, and LV distension). Left and right ventricular unloading should also be assessed via echocardiography. An x-ray or CT of the chest, abdomen, pelvis, and brain, and a CTA of the lungs are other interventions to evaluate the cause of arrest or for possible complications.

Medication Management

There are several considerations in medication management post-cannulation. For management of initiation hypotension, calcium chloride with or without sodium bicarbonate may be administered. Vasopressors and inotropes are also common in the peri- and post-cannulation period in hypotension management. In some cases, once ECLS flow is initiated, vasopressors

may need to be rapidly weaned; however, many (up to 50%) of post-ECPR patients require vasopressors for vasoplegia and the systemic inflammatory response that ensues post-arrest. Fluid and blood products may be given in addition to vasopressors to manage hypotension. Inotropes may help prevent LV distension, especially in cases of narrow pulse pressure (< 10 mmHg) or issues with the aortic valve opening as demonstrated on an echocardiogram.

Anticoagulation is another highly discussed topic in the literature. Intravenous heparin infusions are the primary method of anticoagulation in ECLS patients. The target aPTT range is 40–55 seconds or an initial ACT of 160–220 seconds. aPTT or anti-Xa activity are recommended as the monitoring parameter for heparin infusions. Typically, infusions run at 20–50 units/kg/hour. A heparin infusion for the distal limb perfusion cannula may be added to maintain patency of the cannula. If patients are at a high risk for bleeding, anticoagulation may be avoided for a few days, but there is no clear consensus on this or the timeframe in the literature. If heparin is contraindicated (i.e., hypersensitivity or patient positive for heparin-induced thrombocytopenia), bivalirudin or argatroban may be used in its stead. aPTT values are used to monitor these methods of anticoagulation as well. However, it is important to note that there are no reversal agents for these medications. Therefore, if anticoagulation reversal is indicated, dialysis or administration of fresh frozen plasma is advised.

Other medications to consider are sedatives, analgesics, paralytics, and prophylactic antibiotics (e.g., cefazolin 2g IV Q8H x3 doses). It is important to note that higher infusion rates may be necessary for medications that are lipid-soluble or protein-bound (e.g., fentanyl, propofol, dexmedetomidine), as sequestration in the ECMO circuit is common.

Transportation

While the focus of transportation post-cannulation in the literature is centred on inter-facility transport, this is beyond the scope of this review. Intra-hospital transport is less discussed in the literature; however, there are some recommendations on the transportation process within one facility. The key to a safe and successful transport is preparation and clear delineation of roles for all staff involved. A checklist may be helpful to ensure that all preparations are made prior to moving the patient. Appropriate staff should be present, including a physician, perfusionist, respiratory therapist, nurse, and supporting team members (e.g., security, personal care attendant, porter). Staff should have hallways cleared, elevators held, and ensure the receiving unit is ready for the patient. One person (usually the perfusionist) oversees the transport. Any extra supplies needed should be available, including four tubing clamps, fluids, an extra oxygen tank (ensure tank is full), and a hand crank for the centrifugal pump. Sufficient battery power should be available for all essential transportation equipment. One person should be assigned to keep one hand on the bed and one hand on the ECLS machine cart to ensure no tension is placed on the lines. The patient should be switched to portable monitoring, i.e., ECG, blood pressure, and SPO_2. An appropriate handover should be given to the receiving unit, and the transport documented.

ECPR considerations

There are a few post-cannulation considerations specific to ECPR. If a patient remains in refractory arrest (shockable rhythm) or unstable arrhythmia a few minutes after ECLS flow is achieved or arrests after achieving ROSC, the patient may be defibrillated/cardioverted. Manual or mechanical CPR should not be restarted after ECMO flow is achieved unless flow goals cannot be met and directed to do so by the physician and perfusionist. By doing so, the patient is

placed at risk of accidental decannulation. As previously discussed, mechanical CPR is usually run for about one minute, or until goal flow is achieved, before termination. If an endotracheal tube was placed during the arrest, placement should be verified and connected to a ventilator. An NG tube should be placed and suction applied. Additionally, a 12-lead ECG should be obtained. The cause of arrest needs to be determined if not already known and treated. A cardiac catheterization may be indicated if no cause is found. Finally, temperature should be monitored and managed appropriately as per post-arrest care guidelines.

Other Considerations

There are other miscellaneous considerations, including documentation, patient positioning, staff de-briefing, and terminating ECMO. A post-cannulation checklist is recommended to ensure all tasks and checks are completed prior to transfer or continuing care. Documentation includes cannulation and post-cannulation events, such as the reason for ECLS initiation, time of initiation, patient's response, complications encountered during or after insertion, post-cannulation patient disposition, resuscitation events, site condition, pedal pulses/limb perfusion, marking of insertion site to monitor for cannula migration, time, events, and handover on transfer, and personnel present. Regarding patient positioning, the head of the bed should not exceed 45 degrees to prevent cannula kinking/displacement. As an alternative, the patient may be placed in a reverse Trendelenburg position to avoid hip flexion. Finally, it is important to discuss goals of care with the next of kin. Discussion may be around organ donation or termination of ECMO if the patient's condition is determined to be futile or ECLS is against the patient's wishes.

Complications

Several potential complications can arise from VA-ECMO and ECPR. Twenty-three articles and resources reviewed possible complications during and after cannulation (Abrams et al., 2022; Badulak & Shinar, 2020; Bartos & Yannopoulos, 2020; Bernhardt et al., 2022; Brandorff et al., 2023; Cassara et al., 2022; Chaves et al., 2019; Ciullo & Tonna, 2024; Condella et al., 2025; Douflé et al., 2024; Eckman et al., 2019; ELSO, 2017; HHN, 2025; Kanchi et al., 2022; Karaoğlanoğlu & Akgün, 2023; Keebler et al., 2018; Lorusso et al., 2021; Nanjayya & Murphy (2015a); Napp et al., 2016; Richardson et al., 2021; Swol et al., 2016; Swol et al., 2018; Tsangaris et al., 2021). Many of these would be classified as thromboembolic events (e.g., stroke, clotting of cannula, vessel occlusion, LV thrombosis, pulmonary embolism) or hemorrhagic events (e.g., intracranial, pulmonary, retroperitoneal, gastrointestinal, intramuscular, insertion site bleeding). Issues related to these conditions include systemic coagulopathy and fibrinolysis, and hemolysis. Major vessel dissection or perforation, pseudoaneurysm, nerve damage, transfixation of the inguinal ligament, and accidental decannulation or cannula migration are other vascular complications that may occur. Significant limb ischemia can lead to fasciotomy, compartment splitting, or limb amputation. Hypoperfusion may be seen and lead to multiple organ failure. Systemic or localized infections are also complications seen in ECMO patients. Thoracic trauma and neurological injury from rapid changes in CO_2 are possible complications of ECPR. Equipment failure and circuit rupture were also mentioned as potential complications. Other VA-ECMO-specific complications include differential hypoxemia (Harlequin Syndrome or North-South Syndrome) and LV distension.

Mitigation of risk and improving outcomes for patients for many of these complications can be accomplished through careful monitoring, assessment, and prophylactic interventions. For

example, accidental decannulation or cannula migration can be prevented through appropriate securement of lines, assigning individuals to monitor lines with patient repositioning, adequate sedation and analgesia, and monitoring changes in external cannula positioning (i.e., marking at insertion site and assessing changes in position). Furthermore, careful assessment of end-organ perfusion and limb perfusion with devices (e.g., HemoSphere, Doppler), bloodwork, urine output, etc., allows for early identification and treatment of issues. Prophylactic measures such as timely insertion of a distal limb perfusion catheter and choosing appropriate cannula sizes for patient size and condition can help prevent lower limb ischemia. Prophylactic antibiotics, meticulous insertion site care, and careful assessment for signs of localized or systemic infection may reduce the risk of infection or lead to early identification and treatment. For issues such as ongoing chugging/chattering of lines or evidence of insufficient venous drainage, fluid or blood product administration may be necessary to improve ECMO flow rates. If this does not resolve the issue, an additional venous cannula may need to be inserted.

In complications unique to VA-ECMO, i.e., differential hypoxemia and LV distension, there are certain monitoring considerations and preventative steps to reduce the risk of or identify the presence of these issues. For LV distension, ongoing monitoring for pulmonary edema and the use of ultrasound technology (i.e., POCUS or echocardiogram) can allow for early identification of this condition. Preventative measures include maintaining a MAP between 60–80 mmHg and starting an inotrope. If LV distension is identified, conservative interventions include pharmacological vasodilation, reducing ECMO flow rate, adding inotropes (if not already done), increasing PEEP on ventilator settings, and administration of diuretics. Invasive interventions may include the addition of an LV vent (e.g., Impella), an intra-aortic balloon pump, or an atrial septostomy.

Differential hypoxemia is seen when native cardiac function begins to improve or remains somewhat intact. Diligent monitoring of arterial blood gases from the right radial artery and right upper limb or forehead SPO_2 monitoring allows for identification of this phenomenon. Comparison of oxygenation of the right upper limb to other limbs via these methods can help to confirm the presence of differential hypoxemia. Ventilator management to improve oxygenation via native lung function, ECMO setting titration, and reconfiguration of cannula sites (e.g., femoral arterial access moved to right subclavian access or addition of a venous return cannula) are all interventions that may be considered to treat this condition.

Outcomes

Thirteen articles/resources discussed outcomes of ECLS and ECPR (Abrams et al., 2022; Ali et al., 2024; Bartos & Yannopoulos, 2020; Cassara et al., 2022; Ciullo & Tonna, 2024; Condella et al., 2025; Eckman et al., 2019; Kanchi et al., 2022; Karaoğlanoğlu & Akgün, 2023; Perman et al., 2024; Richardson et al., 2021; Swol et al., 2018; Tsangaris et al., 2021). There is a limited number of randomized controlled trials as supporting evidence for outcomes. Most are observational studies or non-randomized controlled trials, with a few meta-analyses. There were three prominent randomized controlled trials published in the last four years investigating outcomes in ECPR versus usual ACLS care in out-of-hospital cardiac arrest. There are currently no randomized controlled trials that compare outcomes for in-hospital cardiac arrest, with some authors citing the ethical implications of conducting such trials. From this evidence base, there is a wide range of results for outcomes. Many factors are associated with improved functional outcomes, including several of the inclusion and exclusion criteria previously discussed. Higher survival rates and favourable neurological outcomes in ECPR seem to be equivalent to conventional CPR after 60 minutes. Survival rates vary considerably based on indication,

ranging from 8.8–84.2%; an overall survival rate of 41% from the ELSO data registry was reported. It remains unclear in the literature if VA-ECMO and ECPR truly improve survival with favourable outcomes, and for whom.

Implications for Practicum Project

This literature review and environmental scan will provide the evidence base for creating a nursing toolkit for bedside ECMO cannulation. Additionally, consultations with key collaborators at the SJRH will allow the data gathered to be tailored to the current practices used by the cardiovascular surgeons and cannulating team. These consultations will be conducted now that the literature review and environmental scan are complete, as findings will be shared with collaborators to compare recommendations with current practices.

Conclusion

While VA-ECMO and ECPR are not new concepts, they are continuing to evolve with their practice guidelines. There is still a large gap in evidence-based literature and recommendations available to clinicians. This review captured the current global practices and recommendations within the last 10 years to provide an updated practice protocol for the development of a nursing practice resource.

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Appendix

Literature Summary Tables

Table 1

Literature Summary Table for Literature Review

Article	Purpose	Methods	Key Findings	Critical Appraisal
Abrams et al. (2022) Extracorporeal cardiopulmonary resuscitation in adults: Evidence and implications Global perspective	"This review will evaluate the impact of ECPR on survival …, neurological and functional recovery in adults suffering cardiac arrest, identify those most likely to benefit, explore the resources required, and address relevant ethical issues." (p. 2)	Design: Narrative review No. of Studies: 11 Databases Searched: Unclear Data Extraction: Unclear Data Analysis: Unclear Data Synthesis: Unclear	1. ECPR has weak evidence to support use in select patients with reversible etiology of arrest 2. Timing to initiation is variable across studies and institutional guidelines, including needing to wait a minimum amount of time before activation of ECPR team to ensure refractory arrest and limit inappropriate activation; need for balancing waiting time to activation and limiting "low-flow time" 3. Studies show varying initiation recommendations regarding age (60 to 65 years), rhythm (shockable vs. non-	Overall Quality: Low Strengths: Fairly focused review question Limitations: Unclear methods, including databases searched, data extraction, data analysis, and data synthesis; no formal critical appraisal of studies synthesized

Article	Purpose	Methods	Key Findings	Critical Appraisal
			shockable), shorter times from arrest to CPR and CPR to ECPR (CPR for 30, 45, and 60 mins) 4. Ethical considerations - considering the likelihood of survival and neurological recovery, bridging to long-term supportive therapies, reversible causes, organ donation, and code status	
Ali et al. (2024) Extracorporeal cardiopulmonary resuscitation for refractory cardiac arrest: An overview of current practice and evidence Netherlands	" This review summarises current practice and evidence of ECPR in the setting of OHCA." (p. 149)	Design: Narrative review No. of Studies: Unclear total, 3 RCTs Databases Searched: Unclear Data Extraction: Unclear Data Analysis: Pooled RCT results for overall ECPR outcomes by calculating risk ratio	1. Purpose of ECPR 2. Cannulation strategies during ECPR (gauge of cannula and approach/site) 3. Inclusion and exclusion criteria (age, initial rhythm, time to CPR, time to ECMO, ETCO2, signs of life during resuscitation)	Overall Quality: Low Strengths: Fairly focused review question, focuses on all RCTs available for out-of-hospital cardiac arrest Limitations: Unclear methods, including databases

Article	Purpose	Methods	Key Findings	Critical Appraisal
		Data Synthesis: Unclear		searched, data extraction, and data synthesis; limited data analysis; no formal critical appraisal of studies synthesized
Badulak & Shinar (2020) Extracorporeal membrane oxygenation in the emergency department USA	"This article highlights circuit configurations and physiology of ECMO, guidance for running an ECPR code, description of the cannulation procedure, postcircuit initiation critical care, patient selection, and the evidence for use of ECMO." (p. 946)	Design: Narrative review No. of Studies: Unclear Databases Searched: Unclear Data Extraction: Unclear Data Analysis: Unclear Data Synthesis: Unclear	1. "Inclusion criteria for extracorporeal cardiopulmonary resuscitation (ECPR): reversible cause of arrest, witnessed arrest with bystander CPR, total chest compression time of less than 60 minutes, no known preexisting chronic terminal illnesses." (p. 945) 2. "The initiation of ECMO is divided into 3 stages: (1) vascular access, (2) insertion of ECMO cannulas and connection to the circuit once the patient is determined to be an	Overall Quality: Low Strengths: Fairly focused review question Limitations: Unclear methods, including databases searched, data extraction, data analysis, and data synthesis; no formal critical appraisal of studies synthesized

Article	Purpose	Methods	Key Findings	Critical Appraisal
			ECMO candidate, (3) pump initiation." (p. 945) 3. "Post-circuit initiation critical care for ECPR includes establishing an arterial line and managing vasopressors, defibrillation if needed, checking an arterial blood gas on right upper extremity, therapeutic hypothermia, adding an inotrope for LV distention, placing a distal perfusion catheter, and treating the underlying cause of arrest." (p. 945) 4. "Venovenous extracorporeal membrane oxygenation (ECMO) provides pulmonary bypass for severe respiratory failure, and venoarterial ECMO provides cardiac and	

Article	Purpose	Methods	Key Findings	Critical Appraisal
			pulmonary bypass for severe cardiac failure including cardiac arrest." (p. 945)	
Bartos & Yannopoulos (2020) Refractory cardiac arrest: Where extracorporeal cardiopulmonary resuscitation fits USA	"This review will detail where ECPR fits in the current care of cardiac arrest patients, including the key aspects of ECPR deployment and patient selection shown to maximize its benefit." (p. 596)	Design: Narrative review No. of Studies: Unclear Databases Searched: Unclear Data Extraction: Unclear Data Analysis: Unclear Data Synthesis: Unclear	1. Considerations post-ECPR (vasopressors, treatment of underlying cause of arrest, complications such as bleeding and trauma from CPR) 2. Inclusion criteria (65-75 years old or less; presenting rhythm VT/VF; no ROSC after 3 shocks and 15-20 mins of CPR, witnessed arrest and time to CPR; mechanical CPR use; lactic acid and PaO2 levels) 3. Exclusion criteria (sustained ROSC; DNR order; terminal illness of severely impaired functional status at baseline; severe trauma) 4. Cannulation strategy (Seldinger,	Overall Quality: Low Strengths: Fairly focused review question Limitations: Unclear methods, including databases searched, data extraction, data analysis, and data synthesis; no formal critical appraisal of studies synthesized

Article	Purpose	Methods	Key Findings	Critical Appraisal
			surgical cut-down, or hybrid approach) 5. Timing of ECPR (25% reduction in chance of survival with every additional 10 mins of CPR after 30 mins)	
Bernhardt et al. (2022) Extracorporeal membrane oxygenation Germany (Global perspective)	"In this review, we give a detailed description of the common indications, the techniques used, patient monitoring, and weaning from ECMO." (p. 235)	Design: Narrative review No. of Studies: Unclear Databases Searched: PubMed Data Extraction: "selective literature search in PubMed on the topics of cardiogenic shock, ARDS, and ECMO" (p. 235) Data Analysis: Unclear Data Synthesis: Unclear	1. Possible complications and considerations for cannula site 2. Importance of strict patient selection, balancing risks and benefits 3. Inclusion and exclusion criteria for using ECMO to treat cardiogenic shock, including presence of reversible causes, short time from arrest to CPR (less than or equal to 5 mins, not greater than 10 mins) and short time from CPR to ECMO (less than or equal to 60 mins, not greater than 90 mins), age and frailty status	Overall Quality: Low Strengths: Fairly focused review question Limitations: Unclear methods, including data extraction, data analysis, and data synthesis; no formal critical appraisal of studies synthesized; limited search to one database

Article	Purpose	Methods	Key Findings	Critical Appraisal
			(less than 65 years, not older than 75 years), lack of comorbidities, low lactate and balanced pH, etc. 4. Common complications of ECLS for consideration 5. Cannulation strategy	
Brandorff et al. (2023) Extracorporeal membrane oxygenation for cardiac arrest: What, when, why, and how USA (Global perspective)	"In this comprehensive review of extracorporeal cardiopulmonary resuscitation (ECPR), we report the history of resuscitative ECMO, terminology, circuit configuration and cannulation considerations, complications, selection criteria, implementation and management, and important considerations for the provider. We review the relevant	Design: Narrative review No. of Studies: Unclear Databases Searched: Unclear Data Extraction: Unclear Data Analysis: Unclear Data Synthesis: Unclear	1. Cannulation techniques (Seldinger/modified -Seldinger, cutdown), sites (central vs. peripheral), and cannula selection 2. Complications of ECPR 3. Inclusion and exclusion criteria for ECPR (age less than 70, presence of shockable rhythm, comorbidities, less than 5 mins from arrest to CPR, less than 60 mins from arrest to ECMO)	Overall Quality: Low Strengths: Fairly focused review question Limitations: Unclear methods, including databases searched, data extraction, data analysis, and data synthesis; no formal critical appraisal of

Article	Purpose	Methods	Key Findings	Critical Appraisal
	guidelines, different approaches to cannulation, postresuscitation management, and expected outcomes, including neurologic, cardiac and hospital survival. Finally, we advocate for the participation in national/international Registries in order to facilitate continuous quality improvement and support scientific discovery in this evolving area." (p. 1125)			studies synthesized
Cassara et al. (2022) Extracorporeal cardiopulmonary resuscitation: A narrative review and establishment of a sustainable program	"This manuscript will review potential benefits of ECPR on survival and neurologic outcomes, articulate the necessary requirements for building an ECPR program, and briefly review management	Design: Narrative review No. of Studies: Unclear Databases Searched: Unclear Data Extraction: Unclear	1. Potential benefit of improved neurological outcomes in ECPR vs. CPR, mixed evidence 2. Recommendations for ECPR training, including simulations	Overall Quality: Low Strengths: Fairly focused review question Limitations: Unclear methods, including databases

Article	Purpose	Methods	Key Findings	Critical Appraisal
Switzerland (Global perspective)	considerations after cannulation." (p. 1)	Data Analysis: Unclear Data Synthesis: Unclear	3. Timing to ECPR less than or equal to 60 mins 4. Team member responsibilities during ECPR 5. Cannulation technique/approaches during ECPR 6. Post-ECPR patient and team considerations (including interventions, debriefing, and possible complications like LV venting and limb ischemia)	searched, data extraction, data analysis, and data synthesis; no formal critical appraisal of studies synthesized
Chaves et al. (2019) Extracorporeal membrane oxygenation: A literature review Brazil	"The objective of this literature review is to present the theoretical and practical aspects of extracorporeal membrane oxygenation support for respiratory and/or cardiac functions in critically ill patients." (p. 410)	Design: Narrative review No. of Studies: 76 Databases Searched: MEDLINE/PubMed database until December 2018 Data Extraction: Unclear	1. ECMO circuit set up 2. Cannulation technique and sites 3. Indications and outcomes of VA-ECMO 4. Considerations for pre-/post-cannulation and cannulation phases	Overall Quality: Medium Strengths: Fairly focused review question; commented on limitations of studies that evaluated outcomes of VA-ECMO

Article	Purpose	Methods	Key Findings	Critical Appraisal
		Data Analysis: Unclear Data Synthesis: Unclear		and VV-ECMO (literature summary tables) Limitations: Unclear methods, including data extraction, data analysis, and data synthesis; unclear how/if full critical appraisal was completed
Ciullo & Tonna (2024) The state of emergency department extracorporeal cardiopulmonary resuscitation: Where are we now, and where are we going? USA (Global perspective)	"...this review article looks to summarize the application of ECPR, including its current evidence, implementation, and inherent risks and benefits. We also characterize a potential future of ECPR." (p. 2	Design: Narrative review No. of Studies: Unclear Databases Searched: Unclear Data Extraction: Unclear Data Analysis: Unclear Data Synthesis: Unclear	1. Compares the three major trials conducted to evaluate ECPR outcomes in OHCA 2. Inclusion criteria considerations, including age, initial rhythm, down-time and CPR time, comorbidities, and etiology of arrest 3. Post-arrest considerations (percutaneous coronary	Overall Quality: Low Strengths: Fairly focused review question, compares the only three RCTs available on ECPR outcomes Limitations: Unclear methods,

Article	Purpose	Methods	Key Findings	Critical Appraisal
			intervention and treating reversible causes)	including databases searched, data extraction, data analysis, and data synthesis; no formal critical appraisal of studies synthesized
Condella et al. (2025) Extracorporeal membrane oxygenation (ECMO): A narrative review for the emergency clinician USA	"This narrative review discusses the mechanisms by which ECMO stabilizes respiratory or cardiopulmonary failure, the indications for urgent ECMO referral, and the logistical requirements for initiating ECMO in the Emergency Department (ED) with a focus on the emergency clinician." (p. 6)	Design: Narrative review No. of Studies: 94 Databases Searched: Embase, MEDLINE and Google Scholar (first 200 relevant references); keywords: “emergency department,” “extracorporeal membrane oxygenation,” “ECMO,” “ECLS,” and “ECPR”; inception of	1. Considerations for cannulation 2. Considerations post-cannulation 3. Indications for VA-ECMO 4. Inclusion criteria	Overall Quality: Medium Strengths: Included a large number of relevant studies; included meta-analyses, RCTs, narrative reviews, as well as weaker studies; fairly focused review question; also included guidelines

Article	Purpose	Methods	Key Findings	Critical Appraisal
		database to Feb. 1, 2025 Data Extraction: Consensus among authors on what studies to include; searched "case reports and series, retrospective and prospective studies, randomized controlled trials, systematic reviews and meta-analyses, and other narrative reviews. Authors also reviewed guidelines and supporting citations of included articles" (p. 7); focused on stronger evidence, such as reviews, randomized controlled trials, and meta-analyses, when able		Limitations: Data analysis and synthesis unclear; no clear attempt to critically appraise literature/report critical appraisal

Article	Purpose	Methods	Key Findings	Critical Appraisal
		Data Analysis: Unclear Data Synthesis: Unclear		
Douflé et al. (2024) Head-to-toe bedside ultrasound for adult patients on extracorporeal membrane oxygenation Germany (Global perspective)	"This review will provide a comprehensive overview on the role of ultrasound: 1) in the assessment of patients before ECMO initiation; 2) during ECMO cannulation; 3) for monitoring during ECMO support and troubleshooting ECMO complications; and 4) in the assessment of readiness for liberation from ECMO." (p. 633)	Design: Narrative review No. of Studies: Unclear Databases Searched: Unclear Data Extraction: Unclear Data Analysis: Unclear Data Synthesis: Unclear	1. Pre-cannulation considerations, including using ultrasound technology/ echocardiography to determine baseline valve and heart function, eligibility for ECMO, possible reversible causes of arrest or shock, vascular access site(s) eligibility, and choosing cannula size 2. Cannulation considerations, including use of echocardiography during cannulation to guide insertion, determine vessel access, and use of TEE in ECPR, and possible complications with cannula positioning 3. Post-cannulation considerations, including	Overall Quality: Low Strengths: Fairly focused review question Limitations: Unclear methods, including databases searched, data extraction, data analysis, and data synthesis; no formal critical appraisal of studies synthesized

Article	Purpose	Methods	Key Findings	Critical Appraisal
			recommended post-cannulation echocardiography to verify final cannula position, and assessment of ventricular and valvular function post-cannulation	
Eckman et al. (2019) Veno-arterial extracorporeal membrane oxygenation for cardiogenic shock: An introduction for the busy clinician USA	"We provide a practical review for cardiovascular clinicians on the application of veno-arterial extracorporeal membrane oxygenation in adult patients with cardiogenic shock, including epidemiology of cardiogenic shock, indications, contraindications, and the extracorporeal membrane oxygenation circuit. We also summarize cannulation techniques, practical management and troubleshooting, prognosis, and weaning and exit	Design: Narrative review No. of Studies: Unclear Databases Searched: Unclear Data Extraction: Unclear Data Analysis: Unclear Data Synthesis: Unclear	1. Indications for VA-ECMO (cardiac arrest, cardiopulmonary failure) 2. Relative and absolute contraindications, including prognostic scores, valvular disease, hemorrhage, goals of care, and unwitnessed arrest 3. Cannulation summary, including different site options with advantages and disadvantages, cannula size recommendations, anticoagulation recommendations, managing distal limb perfusion	Overall Quality: Low Strengths: Fairly focused review question Limitations: Unclear methods, including databases searched, data extraction, data analysis, and data synthesis; no formal critical appraisal of studies synthesized

Article	Purpose	Methods	Key Findings	Critical Appraisal
	strategies, with attention to end of life and ethical considerations." (p. 2019)		3. Outcomes of ECMO (psychological, physical, functional capacity, mortality), including survival rates, use of prognostic scores, factors improving/ decreasing survival rates (e.g., age, timing of cannulation, pH/lactate levels)	
Kanchi et al. (2022) Extracorporeal membrane oxygenation (ECMO) for pulmonary and/ or cardiopulmonary Support—A brief review and our experience India	The authors reviewed the history of ECMO, indications, types of ECMO and techniques, outcomes and complications of ECMO, the use of ECPR, and maintaining and weaning ECMO.	Design: Narrative review No. of Studies: Unclear Databases Searched: Unclear Data Extraction: Unclear Data Analysis: Unclear Data Synthesis: Unclear	1. Contraindications to ECMO, including absolute and relative 2. Brief explanation of ECMO use and indications, as well as cannula sites for central vs. peripheral ECMO; use of Seldinger technique or cut down 3. Inclusion criteria for ECPR, including no-flow time less than 5 mins, initial rhythm, low-flow time less than 60 mins, and no known aortic regurgitation	Overall Quality: Low Strengths: Fairly focused review question Limitations: Unclear methods, including databases searched, data extraction, data analysis, and data synthesis; no formal critical appraisal of

Article	Purpose	Methods	Key Findings	Critical Appraisal
				studies synthesized
Karaoğlanoğlu & Akgün (2023) Is extracorporeal membrane oxygenation a Panacea? Turkey (Global perspective)	"In this review, we comprehensively discuss the clinical advantages of ECMO, patient selection criteria, indications, contraindications, and its specific role in managing respiratory failure associated with viral pneumonia, which has become increasingly prevalent during the coronavirus disease 2019 (COVID-19) pandemic.3 Key studies are summarized in Table 1, and by incorporating an extensive review of available literature, our aim is to provide valuable insights and guidance for clinical practice in this evolving field." (p. S27)	Design: Narrative review No. of Studies: 15 Databases Searched: Unclear Data Extraction: Unclear Data Analysis: Unclear Data Synthesis: Unclear	1. Explanation of ECMO and circuit 2. Inclusion and exclusion criteria for ECMO and/or ECPR (using predictive scoring, ETCO2 levels, metabolic abnormalities, low-flow time, age, initial rhythm) 3. Indications, including pulmonary embolism and cardiac arrest 4. Contraindications to ECMO, including frailty, BMI, age greater than 65 years, presence of life-limiting conditions, uncontrolled bleeding, cirrhosis, etc.	Overall Quality: Low Strengths: Fairly focused review question; summarized main findings of each study Limitations: Unclear methods, including databases searched, data extraction, data analysis, and data synthesis; no formal critical appraisal of studies synthesized

Article	Purpose	Methods	Key Findings	Critical Appraisal
Keebler et al. (2018) Venoarterial extracorporeal membrane oxygenation in cardiogenic shock USA	"In this review, we focus on VA-ECMO, emphasizing technological advances, patient selection, management and weaning guidelines, outcomes, complications, and economic challenges." (p. 504)	Design: Narrative review No. of Studies: Unclear (34+) Databases Searched: Unclear Data Extraction: Unclear Data Analysis: Unclear Data Synthesis: Unclear	1. ECMO circuit general overview (what ECMO does) 2. Indications and contraindications 3. Other pre-cannulation considerations for eligibility (e.g., all less invasive therapies exhausted, end goal of ECMO, within patient's goals of care, etc.) 4. Inclusion/exclusion criteria for consideration (comorbidities, age, risk scores, etc.) 5. Post-cannulation considerations (right radial arterial line placement, maintaining MAP >60mmHg, in-hospital mortality rates 50-60%, 6-month survival rate around 30%)	Overall Quality: Low Strengths: Fairly focused review question; 12 studies summarized on ECMO outcomes, 22 studies summarized for ECMO complications Limitations: Unclear methods, including databases searched, data extraction, data analysis, and data synthesis; no formal critical appraisal of studies synthesized
Napp et al. (2016)	"Here, we review percutaneous dual and triple cannulation	Design: Narrative review	1. Cannulation sites (femoral vs. upper body)	Overall Quality: Low

Article	Purpose	Methods	Key Findings	Critical Appraisal
Cannulation strategies for percutaneous extracorporeal membrane oxygenation in adults Germany	strategies for different clinical scenarios of the critically ill." (p. 283)	No. of Studies: Unclear (13 studies summarized about triple cannulation) Databases Searched: Unclear Data Extraction: Unclear Data Analysis: Unclear Data Synthesis: Unclear	2. Indications/purpose of ECMO (ECPR, cardiogenic shock, pulmonary embolism, etc.), including bridge-to-transplant, bridge-to-decision, bridge-to-destination 3. Monitoring with right radial arterial line for ECMO complications 4. VA ECMO complications and interventions to monitor/ prevent (e.g., distal limb ischemia - distal perfusion cannula insertion at cannulation)	Strengths: Fairly focused review question; summary of key findings from 13 studies on triple cannulation Limitations: Unclear methods, including databases searched, data extraction, data analysis, and data synthesis; no formal critical appraisal of studies synthesized
Olson et al. (2022) Extracorporeal cardiopulmonary resuscitation in adults and children: A review of	"This review paper aims to summarize key findings from the ECPR literature available to date as well as the recommendations for ECPR set forth by national and	Design: Narrative review No. of Studies: Unclear Databases Searched: Unclear	1. Listed predictors of favourable outcomes for ECPR patients, including age, shockable rhythm, witnessed arrest, temporary ROSC, and shorter times from CPR to ECMO/ arrest to	Overall Quality: Low Strengths: Fairly focused review question

Article	Purpose	Methods	Key Findings	Critical Appraisal
literature, published guidelines and pediatric single-center program building experience USA (Global perspective)	international leading resuscitation societies." (p. 2)	Data Extraction: Unclear Data Analysis: Unclear Data Synthesis: Unclear	ECMO, low initial lactate, and normal pH at baseline, among other inclusion/exclusion criteria 2. Recommendations mixed/ weak evidence for ECPR from four major guideline associations 3. Recommend consulting ECMO team after two rounds of CPR and no ROSC 4. Recommendations for types of training and delivery of education to ECMO staff	Limitations: Unclear methods, including databases searched, data extraction, data analysis, and data synthesis; no formal critical appraisal of studies synthesized
Swol et al. (2016) Conditions and procedures for in-hospital extracorporeal life support (ECLS) in	"We summarize the general structure of an ECLS team and describe the cannulation procedure, the criteria for the use of ECLS, the corresponding indications and	Design: Narrative review No. of Studies: Unclear Databases Searched: Unclear	1. Indications (broad) for ECMO 2. ECMO circuit overview 3. Timing of ECPR (<60 mins from arrest to initiation)	Overall Quality: Low Strengths: Fairly focused review question Limitations: Unclear

Article	Purpose	Methods	Key Findings	Critical Appraisal
cardiopulmonary resuscitation (CPR) of adult patients Global Perspective	exclusion criteria, the required devices and the approaches for post-resuscitation care." (p. 183) "The aim of this article is to support physicians, perfusionists, nurses and ECMO specialists who regularly perform ECPR or are willing to start an ECPR program by establishing standards for safe and efficient ECPR procedures." (p. 182)	Data Extraction: Unclear Data Analysis: Unclear Data Synthesis: Unclear	4. Inclusion criteria for ECPR (witnessed in-hospital cardiac arrest, rapid initiation of CPR, no terminal or futile conditions) 5. Exclusion criteria for ECPR (multiple comorbidities, terminal conditions, morbid obesity, conditions not compatible with life) 6. Ethical considerations (clear goals of care discussion with next of kin or previously known) 7. Pre-cannulation considerations 8. Cannulation considerations (heparin bolus, use of ultrasound/fluoroscopy, cannula sizes) 9. Possible complications of ECPR (high risk for	methods, including databases searched, data extraction, data analysis, and data synthesis; no formal critical appraisal of studies synthesized

Article	Purpose	Methods	Key Findings	Critical Appraisal
			bleed, vessel rupture, limb ischemia) 10. Post-cannulation considerations (diagnostics, plan of care, etc.)	
Swol et al. (2018) Extracorporeal life support in the emergency department: A narrative review for the emergency physician Global perspective	"The intention of this discussion is to review the role of ECLS as a potential rescue method for emergency department (ED) clinicians in critical clinical scenarios and to focus on the prerequisites for managing an ECLS program in an ED setting." (p. 108)	Design: Narrative review No. of Studies: Unclear Databases Searched: Unclear Data Extraction: Unclear Data Analysis: Unclear Data Synthesis: Unclear	1. Cannulation techniques and considerations, with specific comments on cannulation in ECPR 2. Potential complications of ECMO 3. Indications 4. Contraindications 5. Brief overview of ECMO circuit 6. Post-cannulation considerations (anticoagulation during and post-cannulation) 7. Considerations for intrahospital transportation	Overall Quality: Low Strengths: Fairly focused review question; authors from a variety of global locations Limitations: Unclear methods, including databases searched, data extraction, data analysis, and data synthesis; no formal critical appraisal of studies synthesized

Article	Purpose	Methods	Key Findings	Critical Appraisal
			8. Outcomes of ECPR/ ECMO in the ED	
Tsangaris et al. (2021) Overview of veno-arterial extracorporeal membrane oxygenation (VA-ECMO) support for the management of cardiogenic shock USA	"In this review, we discuss the fundamental concepts and hemodynamic aspects of VA-ECMO support in patients with cardiogenic shock of various etiologies. In addition, we review the common indications, contraindications and complications associated with VA-ECMO use." (p. 1)	Design: Narrative review No. of Studies: Unclear (summarized cardiogenic shock definitions from 32 articles) Databases Searched: Unclear Data Extraction: Unclear Data Analysis: Unclear Data Synthesis: Unclear	1. Brief ECMO circuit component overview 2. Cannulation considerations, including cannula locations and sizes (18-29 Fr venous, 15-19 Fr arterial) 3. Timing of ECMO in cardiogenic shock (within 60 mins of recognition and failure of initial therapies) 4. Complications of ECMO (bleeding, limb ischemia) 5. Anticoagulation considerations vary between centres, but many use heparin infusions or bivalirudin 6. List of absolute and relative contraindications	Overall Quality: Low Strengths: Fairly focused review question Limitations: Unclear methods, including databases searched, data extraction, data analysis, and data synthesis; no formal critical appraisal of studies synthesized

Table 2

Literature Summary Table for Clinical Practice Guidelines

Article	Purpose	Methods	Key Findings
ELSO (2017) Extracorporeal life support organization general guidelines for all ECLS cases USA	To describe general practice guidelines on the initiation, maintenance, and discontinuation of ECMO	Professional experience and expert consensus used to create guidelines; no clear literature review or other methods outlined	1. Patient considerations for indications and contraindications of extracorporeal life support use 2. Types of vascular access and cannulation techniques 3. Potential complications of ECMO 4. Special considerations (i.e., transport of ECMO patient) 5. Post-cannulation considerations for ventilation, hemodynamic management, sedation
Gajkowski et al. (2022) ELSO guidelines for adult and pediatric extracorporeal membrane oxygenation circuits USA	To describe and provide guidelines for ECMO circuits and cannulation configurations	Professional experience and expert consensus used to create guidelines; no clear literature review or other methods outlined	1. Cannulation sites, including neck and femoral cannulation 2. Cannula types and selection
Kiss et al. (2025) Initiation and anesthetic	"This journal course will present evidence-based clinical practice	Unclear how the course was created - expert opinion vs. literature review	1. Inclusion criteria for emergent initiation of ECMO in the OR (age,

Article	Purpose	Methods	Key Findings
management of ECMO in the adult noncardiac surgical patient USA	recommendations to guide anesthesia practitioners on the initiation of elective preinduction and emergent ECMO support, and the considerations for intraoperative management of the adult noncardiac surgical patient on ECMO." (p. 301)		CPR time, ETCO2 > 10mmHg, comorbidities) 2. Cannulation and post-cannulation considerations 3. ECPR considerations
Labib et al. (2022) Extracorporeal life support organization guideline for transport and retrieval of adult and pediatric patients with ECMO support USA	To describe practice recommendations for transportation of patients receiving ECMO	Professional experience and expert consensus used to create guidelines; no clear literature review or other methods outlined	1. Importance of team debriefing post-transportation of patient 2. Importance of adequate preparation for transportation 3. Focus primarily on inter-facility transportation, although intra-facility transportation is mentioned
Lorusso et al. (2021) ELSO interim guidelines for venoarterial extracorporeal membrane oxygenation in adult cardiac patients USA	To describe guidelines for the use of venoarterial ECMO in adult cardiac patients, including indications, contraindications, cannulation strategies, management, monitoring,	Professional experience and expert consensus used to create guidelines; no clear literature review or other methods outlined	1. Indications and inclusion criteria for initiating VA ECMO, including characteristics of cardiogenic shock and timing of initiation (within 6 hours of onset of cardiogenic shock) 2. Recommended exclusion criteria, using shock scores in conjunction with clinical data

Article	Purpose	Methods	Key Findings
	complications, and weaning		3. Cannulation strategies (cannula and site selection, technique) 4. Post-cannulation considerations, complications, and monitor suggestions (e.g., VA unloading, radial artery and pulmonary artery line placement, ultrasound/fluoroscopy, mechanical ventilation, hemorrhage) 5. Ethical considerations, family decision-making
Nanjayya & Murphy (2015a) Ultrasound guidance for extra-corporeal membrane oxygenation general guidelines USA	To describe general guidelines for the use of ultrasound technology throughout the ECMO process (all types of ECMO)	Professional experience and expert consensus used to create guidelines; no clear literature review or other methods outlined	1. Use of ultrasound in the pre-cannulation phase (echocardiogram - identifying pathologies that may exclude the patient from ECMO, or may be treated with ECMO, determining the size of cannula to use and site, determining the best type of ECMO therapy) 2. Use of ultrasound in the cannulation phase (visual guidance and confirmation of placement of cannulas, use of transthoracic and transesophageal echocardiograms)

Article	Purpose	Methods	Key Findings
			3. Use of ultrasound in the post-cannulation phase (monitoring and confirming cannula placement, monitoring complications)
Nanjayya & Murphy (2015b) Ultrasound guidance for extra-corporeal membrane oxygenation veno-arterial ECMO specific guidelines USA	To describe ultrasound guidelines specific to veno-arterial ECMO throughout the ECMO process	Professional experience and expert consensus used to create guidelines; no clear literature review or other methods outlined	1. Ultrasound use in the pre-cannulation phase (determine ventricular function, investigate related pathologies, determine cannula size and insertion site) 2. Ultrasound use in the cannulation phase (guidance for placement and verification of location) 3. Ultrasound use in the post-cannulation phase (aid in diagnosing complications of ECMO, verifying and monitoring placement of cannulas, guidance for cardiac function in weaning ECMO)
Oliver et al. (2024) Implementing enhanced extracorporeal membrane oxygenation for CPR (ECPR) in the emergency department	"We describe the process of activation of ECPR, patient selection, and the steps that emergency department clinicians can utilise to facilitate timely cannulation to ensure the best	Experience/expert opinion from the three ECMO centres in Australia; unclear if literature was reviewed in conjunction with this	1. Physical layout for ECPR in ED trauma bay 2. Checklist of tasks for each phase of cannulation and ECPR 3. Inclusion criteria (age, witnessed arrest, initial rhythm, timing of CPR, reversible causes of arrest,

Article	Purpose	Methods	Key Findings
Australia	outcomes for patients in refractory cardiac arrest." (p. 1)		ETCO2 ≥ 10mmHg, time to ECMO) 3. Drug considerations in ECPR 4. Considerations for pre-, peri-, and post-cannulation
Perman et al. (2024) 2023 American Heart Association focused update on adult advanced cardiovascular life support: An update to the American Heart Association guidelines for cardiopulmonary resuscitation and emergency cardiovascular care	An update to the American Heart Association guidelines for cardiopulmonary resuscitation and emergency cardiovascular care	Design: Systematic review as the basis for guideline development No. of Studies: Unclear Databases Searched: Medline and Excerpta Medica Database (Embase), Cochrane Central Register of Controlled Trials (CENTRAL) Data Extraction: 2 independent reviewers screened articles and performed full-text reviews; conflict resolved between screeners and writing group leadership Data Analysis: developed treatment recommendations	1. ECPR is recommended in select patients when staff trained appropriately and adequate resources available 2. Used as bridge-to-treatment to buy time for treatment of reversible causes of arrest 3. Change in recommendation based on 2 recent RCTs

Article	Purpose	Methods	Key Findings
		based on findings from literature review (applied to clinical questions); recommendations classified based on level and strength of evidence used Data Synthesis: 2-3 group members wrote drafts and drafts/final manuscript approved by all members of writing committee; submitted for blind-peer review	
Richardson et al. (2021) Extracorporeal cardiopulmonary resuscitation in adults. Interim guideline consensus statement from the Extracorporeal Life Support Organization Global Perspective (ELSO)	To provide clinical guideline recommendations on the use of ECPR in the adult population.	Professional experience and expert consensus used to create guidelines; no clear literature review or other methods outlined	1. Recommended timing to ECPR (< 60 mins with < 5 mins of no-flow time; waiting 10-20 mins for refractory arrest before initiating ECMO consideration) 2. Limited RCTs 3. Inclusion criteria suggestions (each centre should create their own) 4. Cannulation strategies during ECPR 5. ACLS modifications during and after cannulation

Article	Purpose	Methods	Key Findings
			6. Recommended assessments/interventions immediately post-cannulation and in the following few hours
Rollo et al. (2019) How feasible is extracorporeal cardiopulmonary resuscitation in a medium urban population centre? Atlantic Canada	To determine ECPR criteria for the Saint John Regional Hospital (SJRH) and if an ECPR program is feasible in this setting.	Design: Literature review, modified Delphi survey (13 experts) No. of Studies: 6 in literature review Databases searched: Unclear Data Extraction: Unclear for literature review; determination of ECPR guidelines for setting determined by expert opinion (13 experts) via modified Delphi survey (3 rounds - 60% consensus threshold for moving on to next round, 80%) and final consensus rate required) review by an international expert; estimation of ECPR frequency in setting determined by database review	1. Inclusion and exclusion criteria for ECPR activation (100% consensus rate) 2. It is feasible to keep up competency and maintain an ECPR program at the SJRH

Article	Purpose	Methods	Key Findings
		and health record search Data Analysis: standard parametric and non-parametric measures for ECPR rates; unclear for literature review Data Synthesis: Unclear	

Table 3

Literature Summary Table for Clinical Practice Resources

Source	Resource	Key Findings
Department of Critical Care Medicine Calgary (Foothills Medical Centre CVICU) – Calgary, Alberta	Extracorporeal Life Support (ECLS) Reference Document	1. Reviews indications of VA-ECMO 2. Pre-cannulation considerations (prophylactic antibiotics, cannulation sites, bloodwork, anticoagulant boluses, equipment to be available for OR team/MD, preparation of room and patient, administration of blood products) 3. Post-cannulation considerations (documentation, site assessment, O2 monitoring, ventilation changes, medication administration) 4. Intrahospital transportation considerations (supplies/equipment) 5. Patient management/considerations in emergency situations (ECPR)
Horizon Health Network (Saint John	Extracorporeal Membrane	1. Inclusion and exclusion criteria for VA-ECMO

Source	Resource	Key Findings
Regional Hospital MSICU) – Saint John, New Brunswick	Oxygenation (ECMO) Learning Package for Registered Nurses in Critical Care	2. Cannulation and post-cannulation considerations 3. Set up for ECPR in the emergency department 4. Management of cardiac arrest post-ECMO
Vancouver Coastal Health (Vancouver General Hospital) – Vancouver, British Columbia	Extracorporeal Life Support (ECLS) Initiation	1. RN responsibilities checklist (along with other checklists of responsibilities of other team members) 2. Pre-/post-cannulation and cannulation considerations/ supplies 3. Documentation 4. Inclusion criteria

Appendix B

Consultation Report

A Nursing Toolkit for the Bedside Insertion of Extracorporeal Membrane Oxygenation (ECMO) in the Coronary Care Unit

Background

The goal of this project is to develop an educational resource (toolkit) for nurses in a coronary care unit (CCU) to guide nursing care during bedside extracorporeal membrane oxygenation (ECMO) cannulation. A literature review and environmental scan were conducted to inform the content of the nursing toolkit. Consultations were then undertaken to tailor the nursing toolkit to the needs of the specific nursing unit for which it is intended.

Methodology

Purposive sampling was used to obtain a sample of four employees involved in the care of patients in the CCU. They were consulted regarding their thoughts on the creation and content of a nursing toolkit for bedside ECMO cannulation. Three participants were nursing staff, and one was a physician. A second physician was contacted for consultation, but no response was received. They were selected based on years of experience in CCU, previous experience with ECMO cannulation in CCU, and current roles. Participants were contacted either in person or by email to ask whether they were willing to participate in consultations.

A group interview with the nursing staff and a private interview with the physician were conducted in person. This provided a comfortable setting for all participants to share their thoughts on the ECMO process in CCU. In the group context, it allowed participants to hear others' ideas and branch off with their own to add to the conversation. The two in-person consultation sessions were recorded on my iPhone using the Voice Memos app. Consultants were

asked a series of pre-determined, open-ended questions (see Appendix A). After all data were collected, I extracted data into tables, coded the data, and identified categories through inductive content analysis to describe the considerations and issues experienced during the peri-cannulation period in the CCU (Elo & Kyngäs, 2008; Kleinheksel et al., 2020; Meier, 2017). This method was chosen because I wanted to describe the manifest content of interviews for translation into the content of the nursing toolkit (Elo & Kyngäs, 2008). Results from the consultations are provided below.

Ethical Considerations

Ethical approval was not required, as this project is classified as a quality-improvement project (see Appendix B). Verbal consent was obtained from all participants to participate in and record the interview. The recordings will be permanently deleted after completion of this report. None of the participants' names were used in the reporting process, and clinical roles have been kept vague to maintain confidentiality.

Results

While coding the data, I noticed that topics covered in both the physician interview and the nursing focus group had some similarities, as well as many differences. Since there were several differences in the data collected between groups, I decided to categorize and present the findings for each group separately.

Demographic Information

There were four participants in total, although five were originally invited to participate in consultations. A physician (ECMO cannulator) and three registered nurses of varying clinical roles were selected for consultations. Each participant had greater than 5 years of recent or current experience in CCU or the cardiac OR. The selected nurses had all been involved in some

capacity or witnessed ECMO cannulation in CCU. All three nurses had worked as bedside nurses in the CCU in some capacity. Participants were selected based on their current roles, experience with ECMO cannulation in CCU, and years of experience in CCU.

Findings from the Nursing Focus Group

A few categories were generated during the content analysis of the data. For the nursing staff, these included Unclear Roles and Expectations, Clear Layout of Tasks/Information, Unfamiliar Territory, and Others as Experts, as well as suggestions for the format and content of the nursing tookit.

Unclear Roles and Expectations

Throughout the interview, it was expressed by the nursing staff that they do not feel confident in knowing what their role is, nor the expectations that are placed on them. Many examples were given, including whether it was expected that they stay in the room during cannulation or not; uncertainty of what exactly the surgeon and OR team expected them to do to prepare the patient/room for their arrival; whether central lines were needing to be placed in CCU versus after transfer; misunderstanding of the cannulation process; and a knowledge deficit about ECMO and its indications. They expressed wanting to know "what [the surgeons] want done where" (Nurse 2) so that they can prepare the room and patient appropriately to ease the cannulation process. "We just want to know a process" (Nurse 2). Communication breakdown between the cannulating and CCU teams has occurred, driven by an unclear understanding of roles and expectations from both teams.

Clear Layout of Tasks and Information

Another category that was identified was the need for a clear layout of tasks and information. Without a clear sense of the roles or expectations for the CCU team, the nurses

articulated a willingness to learn whatever is needed so that they can provide support to the cannulating team. Issues with the current awareness of the location of ECMO supplies on the unit and the contents of the corresponding preparation checklist were brought up in the interview. One nurse recalled the unit's introduction to the satellite ECMO bin and the misunderstanding of expected task completion:

> Yeah, because our intro, [former nurse manager] brought this bucket from the OR. So, there's a bucket under the fridge, and the checklist was taped to the wall in where the new computer desk is. She said, "Move the bed into the centre of the room and get two over bed tables and turn on the light. After that, close the door, you're out." It's not that simple. It's not that quick of a set up. And they're your patient, like, you're not out after that. (Nurse 2)

It was suggested to redo the satellite ECMO bin (i.e., bin of supplies stored on CCU for cannulation) checklist to give in-depth steps of the tasks listed. For example, listing the steps to activating protocol for STAT blood products, something with which they expressed many people on the unit are unfamiliar. Another example was the order in which the tasks are listed and clarifying which needs to be done first, what can be done simultaneously, and so forth. Furthermore, the nurses wanted a clearer understanding of what supplies or equipment the surgeons require, as some of the items listed on the current checklist have gone unused or have been in the way during cannulation. The nurses also indicated wanting more information on the basics of ECMO and its indications.

Unfamiliar Territory

A sense of being in unfamiliar territory was derived from the data. The nursing staff reported that not many people on the CCU have seen or been actively involved in ECMO

cannulation at the bedside. There have been varying experiences among nurses who have seen ECMO cannulation in CCU, describing each experience as unique. This was also represented in the team dynamics between the CCU and OR staff, with some experiences being calm and inclusive, while others have been chaotic. One nurse expressed feeling as though the cannulating surgeon thinks that "we don't know what we're doing, which is really not the case. It's that we're doing something very unfamiliar" (Nurse 2).

As previously stated, there is a large knowledge deficit and a lack of clear role delineation for CCU staff, creating tumultuous situations when trying to navigate unfamiliar territory. Nursing staff revealed that they do not think that they will ever be experts or have an official competency with ECMO cannulation; however, they felt that having a resource to create familiarity with ECMO cannulation could diffuse some of the tension and uncertainty when involved in this procedure. The nurses are willing to participate if it is clear what they are meant to do and they have more familiarity with the procedure. It was expressed by one nurse that a nursing toolkit could provide them with information and a plan "so that when they come up, we're not panicked" (Nurse 1).

Others as Experts

As previously stated, the nurses did not think that being an expert in ECMO cannulation or being officially competent in ECMO cannulation assistance/preparation was a foreseeable reality. One nurse stated, "I don't think we're ever going to have competency in this" (Nurse 1). "…the competency really relies with the team. That's their thing. So you can support that team to get it done efficiently" (Nurse 2). They cited that competency in this process lies with the OR team. However, they articulated that they felt a resource could provide them with the knowledge

to understand what is happening and why, as well as how they can support the cannulating team in order to provide efficient care for their patients.

Resource Suggestions

There were a few recommendations for the format and content of the nursing resource toolkit. It was suggested that a photo of the room set up would be helpful to ensure all equipment and patient positioning are appropriate when the cannulating team arrives. A set of laminated checklists for each stage of the cannulation process (i.e., pre-cannulation preparation, cannulation, post-cannulation/ preparation for transport, and ECPR algorithm) to be kept with the ECMO satellite bin would be the most helpful to the team while at the bedside. The nurses also agreed that a video with or without a PowerPoint presentation about the basics of ECMO, its indications, contents of the ECMO bin, and other expectations of the CCU team would be beneficial and is the best format for more in-depth information delivery (as opposed to a typed document). These resources would provide the nursing team with clear direction on roles, responsibilities, and expectations to guide nursing practice and care for critically ill patients. One nurse articulated their thoughts on the usefulness of the nursing toolkit:

> Yeah, I think those are all, like, good things, like, just having a little packet or something that people can refer to and just have generalized knowledge. Like, maybe not so, like, competent, but enough that you understand what is, why we're doing it, where the bucket is. (Nurse 3)

Findings from the Physician Interview

There were several categories assigned to the data from the interview with the physician. These included Inclusion and Exclusion Criteria, Environmental Preparation, Cannulation, Post-

Cannulation Considerations, ECPR Considerations, Unit Culture and Expectations, and Resource Suggestions.

Inclusion and Exclusion Criteria

The physician described the difficult situation of considering a patient for ECMO, and the loose criteria usually considered. Although each patient's situation is unique and it is "hard to script it down" as a concrete set of guidelines, there is a "rough set of guidelines we follow" (Physician). Usually, candidates are less than 70 years of age, have a viable exit strategy, lack end-stage comorbidities, and are seen as having a higher chance of survival if placed on ECMO. This largely depends on the severity of "body insult" (Physician) and the length of time they have been in that state. The physician expressed that there are different considerations based on the patient's acuity. For example, a patient who is actively arresting and receiving CPR may be considered for cannulation if less than 65 years of age. The major takeaway from the interview was that consideration for ECMO is an in-the-moment decision with the best information that they have and varies between patients.

Environmental Preparation

Another major category was environmental preparation. This included preparing the patient and physical environment, as well as having all appropriate equipment and supplies readily available. The physician described arriving at times and finding the room "full of stuff, [the patient] cock-eyed in the bed, rails up, light not on" and having to "spend five minutes just trying to get them in a position where we could start". It was recommended that CCU have the patient positioned in the centre of the bed, both groins exposed and shaved, hair debris removed, the headboard and footboard removed with the bed out from the wall, the lights all on, and extra furniture or equipment removed from the room. The shaving of the groin should be "more

aggressive" (Physician), i.e., the larger the space shaved, the better. Hair debris can be removed with tape or the sticky mitts available in the ECMO bin. If the patient already has femoral venous or arterial access, the dressings should be pulled down, shave prep touched up with hair debris removed, and a sterile towel placed over the site to prepare for post-cannulation line insertion.

The satellite ECMO bins were discussed, and the physician described wanting to have them available in the room with the additional equipment and supplies CCU can provide. For equipment, this includes a bedside ultrasound machine plugged in at the bedside, the line cart outside of the room, and the ACLS cart in the room or close by. Instead of the 2 bedside tables that are listed on the current checklist, the physician would prefer to have an OR table from the OR on CCU or the SICU. For supplies, lines for blood products, an epinephrine drip, and an arterial line setup should be primed. Additionally, if no central venous line or arterial line is already present, the CCU physician does not need to attempt insertion, as the surgeon will insert lines after ECMO initiation.

Cannulation

There were only a few things mentioned that were grouped under cannulation. The first was the technique for cannulation normally used by the physician – "a quick cut-down and do open percutaneous" during a cardiac arrest, and "if they have a pulse, I do it with ultrasound, and a needle and wire" (Physician). Usually, one groin is used for ECMO cannulation, and the other for central venous and arterial access for monitoring and medication administration. The bedside ultrasound would be used during the percutaneous approach. The other thing that was mentioned about cannulation was the responsibilities of the nurse assisting with cannulation. The two major tasks an assistant would be required to do are threading dilators and cannulas on and off the guidewires and using a bulb syringe to de-air cannulas before connecting the ECMO circuit. The

final thing to anticipate is the need for intubation before or during cannulation if the patient is not already intubated. The bedside nurse needs to monitor vital signs, cardiac rhythm, and sedation levels, as well as administer any medications requested during the cannulation procedure. The patient should be well sedated for cannulation to prevent movement.

Post-cannulation Considerations

There were a few post-cannulation considerations that were brought forward. The first was ensuring staff are aware not to cover the groin as doing so can obstruct visualization of bleeding at the site, and blankets could kink the distal perfusion catheter (if placed in CCU). Once an arterial line is placed for monitoring, a blood gas should be collected and sent from the CCU before transfer. If the patient is still in CCU when the results come back, and the patient's pH needs to be corrected, the nurses can anticipate administering IV bicarbonate, e.g., "four amps" (Physician). There may also be a need for calcium administration, as well as blood products (should have 2 units of packed red blood cells and 500 mL albumin available on the floor for administration). Vasopressors may need to be rapidly weaned or titrated up, depending on the patient's blood pressure. An arterial line needs to be established in order to obtain an accurate blood pressure. The initial reading may have a flat arterial line waveform with little to no pulse pressure. The goal is to have a pulse pressure of around 15mmHg or more. As pH is corrected, inotropes started, and/or calcium is administered, an increased pulse pressure should be seen. If the pulse pressure remains non-existent or low, the patient may need a left ventricular vent placed in the OR or cath lab. A transport monitor and defibrillator should be connected to the patient for transport to monitor cardiac rhythm and blood pressure, as "a defib monitor is insufficient" (Physician).

ECPR Considerations

One of the main considerations for cannulation during a cardiac arrest is the need for two teams working together – one for cannulating and one for running the code. The surgeon cannulating cannot run the code while cannulating. The physician explained that there have been times when people seem to forget that the code is going on because cannulation has started, and "no one is doing anything… because of what's going on, they forget that they have to keep running the code" (Physician). The cannulating physician will collaborate with the code team leader to update on what is needed during the code (e.g., pausing compressions for wire access). "You are still in charge of the resuscitation, and I will let you know what I need from an ECMO point of view" (Physician). Another consideration is the alteration in the ACLS algorithm for cardiac arrest during cannulation. Once wires are placed, epinephrine should no longer be given as ECMO will be initiated within the next couple of minutes. Additionally, once it has been decided that ECMO cannulation is happening and the cannulating team is ready to start, there should not be any pauses in compressions for rhythm checks unless directed by the cannulating physician. The physician who was interviewed explained that even if an organized rhythm is obtained, the patient still needs to be placed on ECMO, so the focus should be on establishing ECMO access and providing good compressions. Epinephrine boluses may continue as normal until wire placement. Compressions should continue for about one to two minutes after ECMO flow is initiated, and the cannulating surgeon will let the code team know when to stop compressions. This helps with minimizing left ventricular distension and improving the likelihood of successful defibrillation once on ECMO. It should also be anticipated that norepinephrine or epinephrine and volume (i.e., blood products) will be needed after return of circulation is achieved. An arterial line is the next priority after ECMO circulation has been

achieved, as the cuff is not always accurate. Additionally, a palpable pulse may not be present initially.

Unit Culture and Expectations

The physician described scenarios where they have come up to the floor to begin cannulating, and nothing on the checklist is completed, the ECMO bin is not in the room, and the patient and room are not prepped. Staff expressed to the physician that they were unsure of whether they were expected to complete the checklist. The physician stated:

> I think people are hesitant or they don't want to do something that they weren't supposed to do or that it might impact things. Whereas, you know, the things on that list are all very, they don't, there's no potential to cause harm or disrupt the process, and all they do is help expedite things.

During the interview, the physician expressed their willingness to contribute to a nursing resource in any way that would be helpful, and thought that modification of the current checklist to something that was more user-friendly for the nursing staff was a good solution. Another issue the physician raised was the primary nurse leaving the bedside when the cannulation team arrives. "Often when we arrive, the bedside nurse leaves. I think … they don't want to be in the way" (Physician). They expressed wanting the primary nurse and CCU physician at the bedside to assist with monitoring, sharing of information about the patient, and medication management. They also suggested having at least one nurse outside of the room to be able to run for supplies as needed. "The people who are caring for that patient, we want there, they're important, they're valued, and I view them as a part of the team, for what we're accomplishing" (Physician). It was suggested to have role assignment clearly marked on the ECMO checklist, so that all staff are aware of who is needed to stay even after the cannulating team has arrived. Additionally, the

physician expressed that they thought that increasing familiarity with ECMO through a nursing toolkit could help the CCU team to shift their focus from feeling overwhelmed and out of place to looking for ways that they can help. “I’ve never had a situation where someone has brought something up that was counterproductive. It’s either neutral or very helpful…. So I think having people feel comfortable to voice an opinion or a concern, I always really value [that]”. By “demystifying” the process, the physician expressed hope that this would help the team dynamics to improve.

Resource Suggestions

There were a few broad suggestions given by the physician. Mainly, they seemed agreeable to modifying the current checklist/ creating new checklists to help nurses feel more comfortable at the bedside and expedite preparations. Additionally, they expressed willingness to participate in a simulation video or a video where they talked through the procedure, if this would be helpful for nursing education in CCU. Overall, they were supportive of any resource and additional education that would support the CCU nursing staff in assisting with caring for patients needing ECMO.

Implications for Practicum Project

The results of these consultations with staff shed light on areas for improvement regarding the bedside ECMO cannulation process in CCU. In particular, clear role delineation and task instructions, basic knowledge on ECMO and its indications, and confidence in participation in the peri-cannulation period are lacking. Through the results and recommendations of staff, I will be able to create a toolkit that is useful to the staff in CCU. This includes a tailored format and content of the toolkit. It was determined that an educational video with corresponding PowerPoint and updated checklists would be the most helpful for nursing

staff in CCU. Drawing from these consultations, the creation and implementation of the ECMO nursing toolkit represents a significant step toward standardizing high-acuity, low-frequency procedures within the Coronary Care Unit, establishing a precedent for managing other time-critical interventions.

Conclusion

Through this consultation process, key issues and solutions have been identified in the bedside ECMO cannulation experiences of CCU nurses and a physician. The results of this consultation process will provide tailored content and a suitable format for the nursing resource I will develop next semester. In particular, it was recommended that a presentation on the basics of ECMO and the ECMO satellite bin, as well as laminated bedside checklists for all phases of the ECMO cannulation process, would be helpful solutions to the ECMO-related knowledge deficit identified.

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Appendix A
Interview Guide

Questions for Nursing Staff

1. (Present options for toolkit structure/contents.) Do you think any of these options would be helpful to your/other nurses' practice?
2. Considering current staffing levels and the emergent nature of ECMO, what format (e.g., laminated card, app link, binder) is the most feasible and accessible for quick reference at the bedside? Do you have any suggestions or ideas for alternative delivery methods?
3. Briefly review content that is likely to be included in the toolkit (i.e., pre-cannulation, cannulation, and post-cannulation expectations; code management during ECMO insertion). Beyond technical knowledge, what other barriers (e.g., equipment availability, storage, communication breakdown) currently make preparing for or assisting with ECMO insertion challenging?
4. How could this new ECMO toolkit be best integrated into the current CCU nursing orientation or mandatory annual training schedule to ensure all staff are competent?

Questions for Physician

1. What are your expectations of the CCU team in preparation for bedside ECMO cannulation?
2. What are your expectations of the CCU team in the event of cardiac arrest before or during ECMO insertion?
3. What are your expectations of the CCU team in the event that the OR team is unavailable at the time cannulation must begin?
4. Are there any suggestions you have as to content for a nursing resource for bedside ECMO cannulation?
5. What is the single most common or critical error you see the CCU team make during bedside ECMO insertion, and what specific step could a resource emphasize to mitigate this risk?
6. What are the immediate critical nursing checks (e.g., line placement, patient position, securing the circuit) that must be done before the transport team takes over to move the patient to SICU?

Appendix B
Health Research Ethics Authority (HREA) Screening Tool

Student Name: Anna Raghunanan
Title of Practicum Project: A Nursing Toolkit for the Bedside Insertion of Extracorporeal Membrane Oxygenation (ECMO) in the Coronary Care Unit
Date Checklist Completed: October 30, 2025

This project is exempt from Health Research Ethics Board approval because it matches item number 3 from the list below.

1. Research that relies exclusively on publicly available information when the information is legally accessible to the public and appropriately protected by law; or the information is publicly accessible and there is no reasonable expectation of privacy.
2. Research involving naturalistic observation in public places (where it does not involve any intervention staged by the researcher, or direct interaction with the individual or groups; individuals or groups targeted for observation have no reasonable expectation of privacy; and any dissemination of research results does not allow identification of specific individuals).
3. Quality assurance and quality improvement studies, program evaluation activities, performance reviews, and testing within normal educational requirements if there is no research question involved (used exclusively for assessment, management or improvement purposes).
4. Research based on review of published/publicly reported literature.
5. Research exclusively involving secondary use of anonymous information or anonymous human biological materials, so long as the process of data linkage or recording or dissemination of results does not generate identifiable information.
6. Research based solely on the researcher's personal reflections and self-observation (e.g. auto-ethnography).
7. Case reports.
8. Creative practice activities (where an artist makes or interprets a work or works of art).

For more information please visit the Health Research Ethics Authority (HREA) at https://rpresources.mun.ca/triage/is-your-project-exempt-from-review/

Appendix C

Resource (Checklists)

1

BEDSIDE ECMO CANNULATION BOOKLET

Table of Contents

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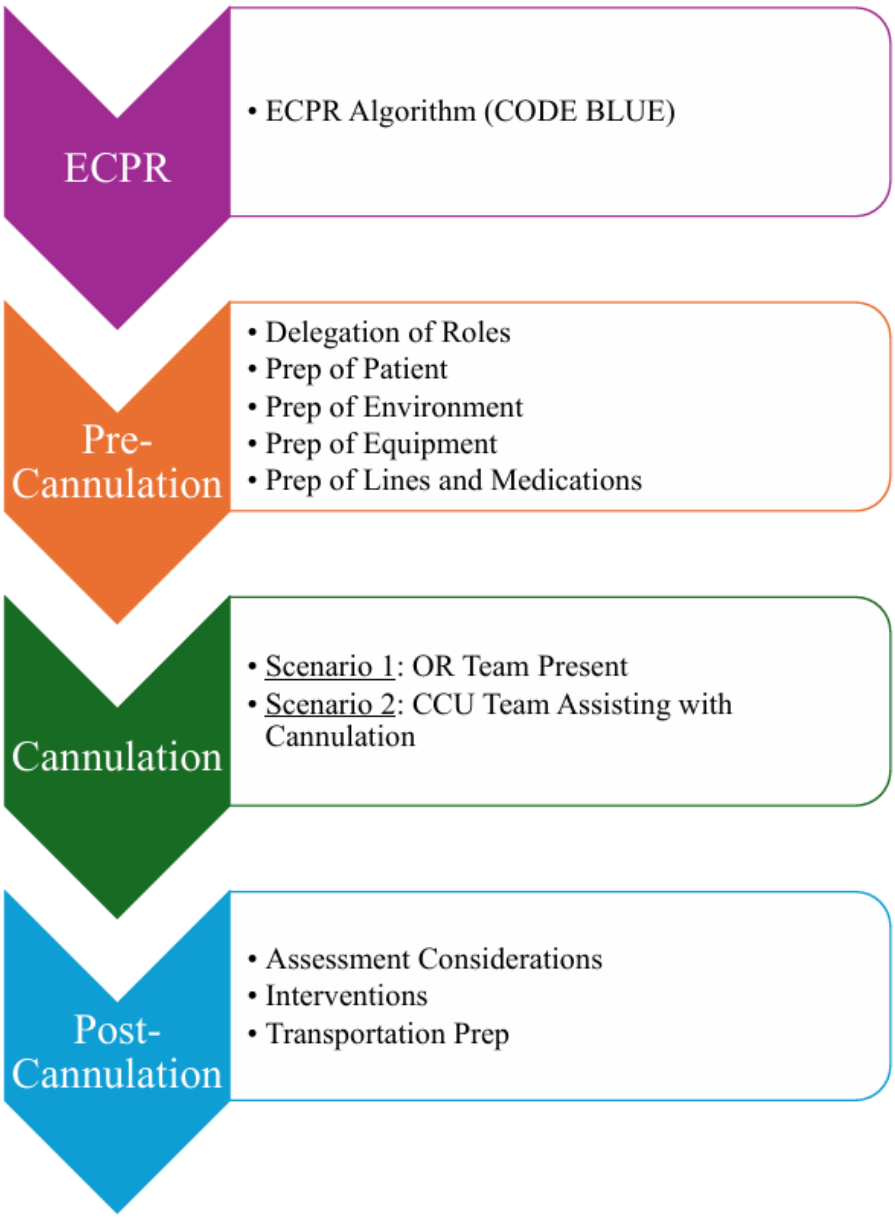
ECMO Cannulation Roadmap



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ECMO Pre-Cannulation Checklist

NOTE that tasks should be performed simultaneously for timely preparation for ECMO cannulation. Check off each task as it is completed.

Delegation of Roles

	TEAM LEADERS include the ***CCU attending physician*** (responsible for running a CODE BLUE and managing the patient's condition/ongoing resuscitation) and the ***cardiac surgeon*** (responsible for cannulation). Both teams should communicate what is needed from the other team.
	Primary Nurse: remains in the room to provide information to the cannulating team; manage the patient; administer medications and titrate gtts PRN
	CCU Attending Physician: remains in the room to provide information to the cannulating team, if possible; facilitates ongoing resuscitation; runs CODE BLUE, as applicable
	Charge Nurse: remains just outside of room with WOW; **calls SICU (6713) as soon as plan for ECMO cannulation is confirmed to prepare bed for transfer**; **calls RT to notify patient going on ECMO/intubation plan, as applicable**; enters orders in I3; makes phone calls; crowd control
	Runner: remains outside of room with charge RN; runs for supplies PRN; assists charge RN with phone calls PRN; crowd control; mixes gtts PRN
	Secondary Nurse(s): remains in room with primary nurse; documents actions of CCU team; monitors VS; assists primary nurse with tasks PRN
	All other nursing staff and ***family members*** should NOT be in the room to prevent congestion unless otherwise instructed/needed or in the case of a CODE BLUE. The ***charge nurse*** or additional ***floor nurse*** should help with crowd control.
	IN EVENT OF CODE BLUE: 6-Person High Performance ACLS Team Roles 1. Team Lead (CCU Attending) 2. CPR/LUCAS 3. Medication Administration 4. Defib 5. Airway 6. Recorder

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Preparation of the Patient (See Patient Positioning Photo)

	Position the patient in the centre of the bed in the supine position.
	Ensure the head of bed/foot of bed is flat and remove pillows and extra linen from the bed/room.
	Shave bilateral groins and remove hair debris with hair removal kit sticky mitts (BAG 2 in ECMO bin) or tape. Shave LARGE areas; the more hair removed, the better. Think area of your hand with fingers spread out.
	Cleanse groins with CHG wipes.
	If IABP or femoral central lines are already in place, remove the dressing(s), touch up shave prep if needed, and remove hair debris. Place sterile OR towels over the site(s).
	Place a **green** Johnny shirt on the patient (**if time permits and not planning to go to the cath lab**).

Preparation of the Environment (See Room Setup Photo)

	Remove all equipment, supplies, furniture, and people from the room that are not needed for cannulation (e.g., bedside tables, over-bed tables, chairs, personal belongings, etc.).
	Clear clutter from the hallway outside of the room and leading out of the unit for ease of transportation after cannulation and for the OR equipment/perfusion supply cart.
	Pull the bed out from the wall into the centre of the room. Remove foot and headboards.
	Raise the bed to waist-height and put down ALL side rails.
	Turn on ALL lights.

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Preparation of Equipment

	Retrieve the ECMO OR-style table from the med room. Position it at the end of the bed.
	Retrieve the ECMO bin and have it in the room.
	Place a biohazard (YELLOW) garbage can in the room.
	Retrieve a crash cart and have it in the corner of the room.
	Have LUCAS available in the room if performing CPR OR a CODE BLUE is expected. Consider applying **before** cannulation begins.
	Retrieve bedside ultrasound machine and have it plugged in at the bedside with sterile probe covers (in Line Cart/ECMO bin).
	Position the line cart OUTSIDE of the room.
	Ensure enough PPE is available to staff, as applicable.
	Place WOW in the hallway (plugged in) to enter orders.

Preparation of Lines and Medications

	Obtain a group and crossmatch if not already completed (should have been done within the last 96 hours).
	Ensure a panel of bloodwork has been sent today (CBC, electrolytes, Mg, aPTT, INR, Cr). If not, and time permits, send missing bloodwork STAT. Check with CCU attending or cardiac surgeon for bloodwork orders.
	See the '**Ordering Blood Products**' section for more details. If Hgb is less than 100, anticipate ordering 2 units of RBCs STAT. Call to send up BOTH units STAT. If Hgb is greater than or equal to 100, anticipate ordering albumin 5% 500 mL STAT.
	Place 2 units of RBCs on hold (in addition to STAT albumin or RBCs).
	Prime blood tubing as per the above blood product choice. Plan to administer shortly after cannulation is complete.
	Draw up heparin 5,000 units in a syringe and have it ready in the room (labelled).

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	Mix an epinephrine gtt with a primed line and have it available in the room.
	Prime an arterial line set up if the patient does not already have one in place. Ensure arterial line monitoring cables are available with setup in the room.
	See '**Interventions**' on the '**Post-Cannulation Checklist**' for other possible medications to be given post-cannulation. Ask cardiac surgeon or CCU attending for sedation/vasopressor orders as needed.

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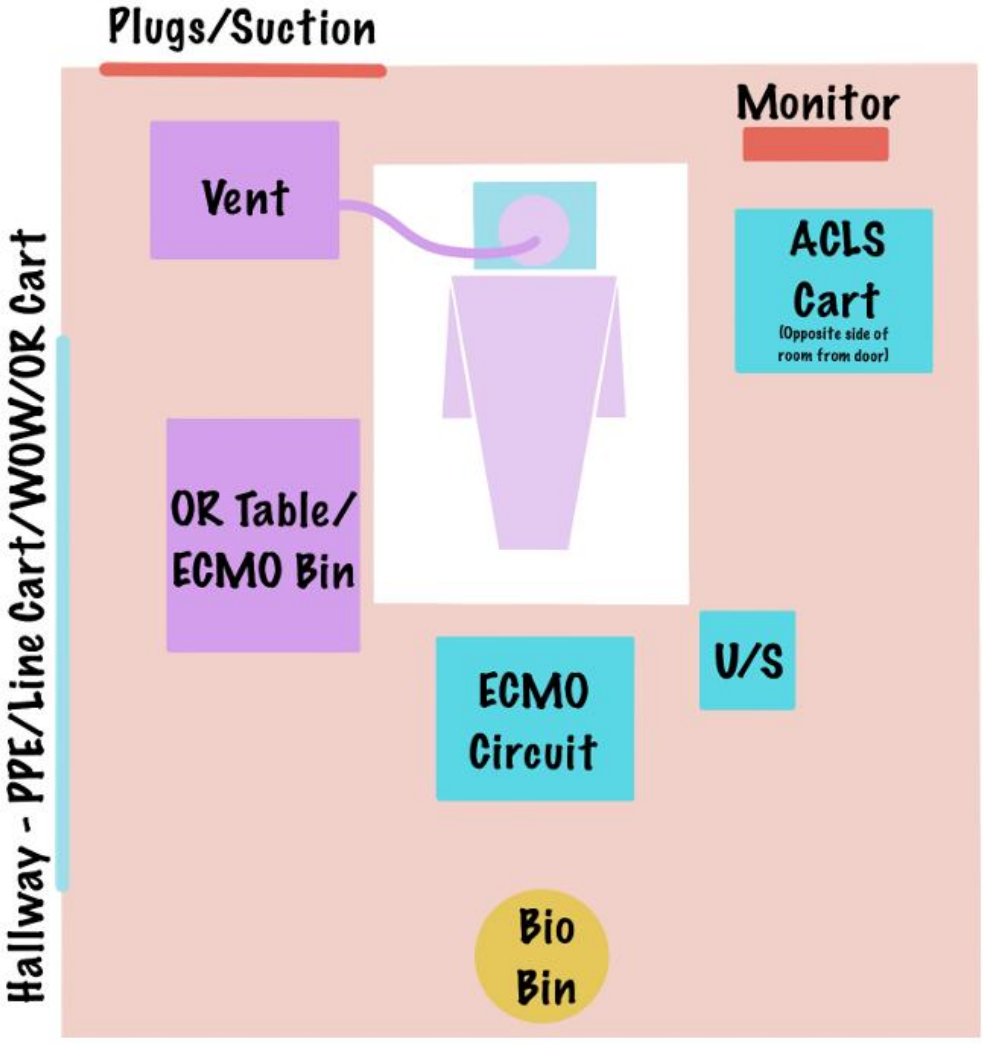
Room Setup Photo

__NOTE__ that the position of equipment can be changed based on MD preference/room setup. Ensure everything is plugged in.



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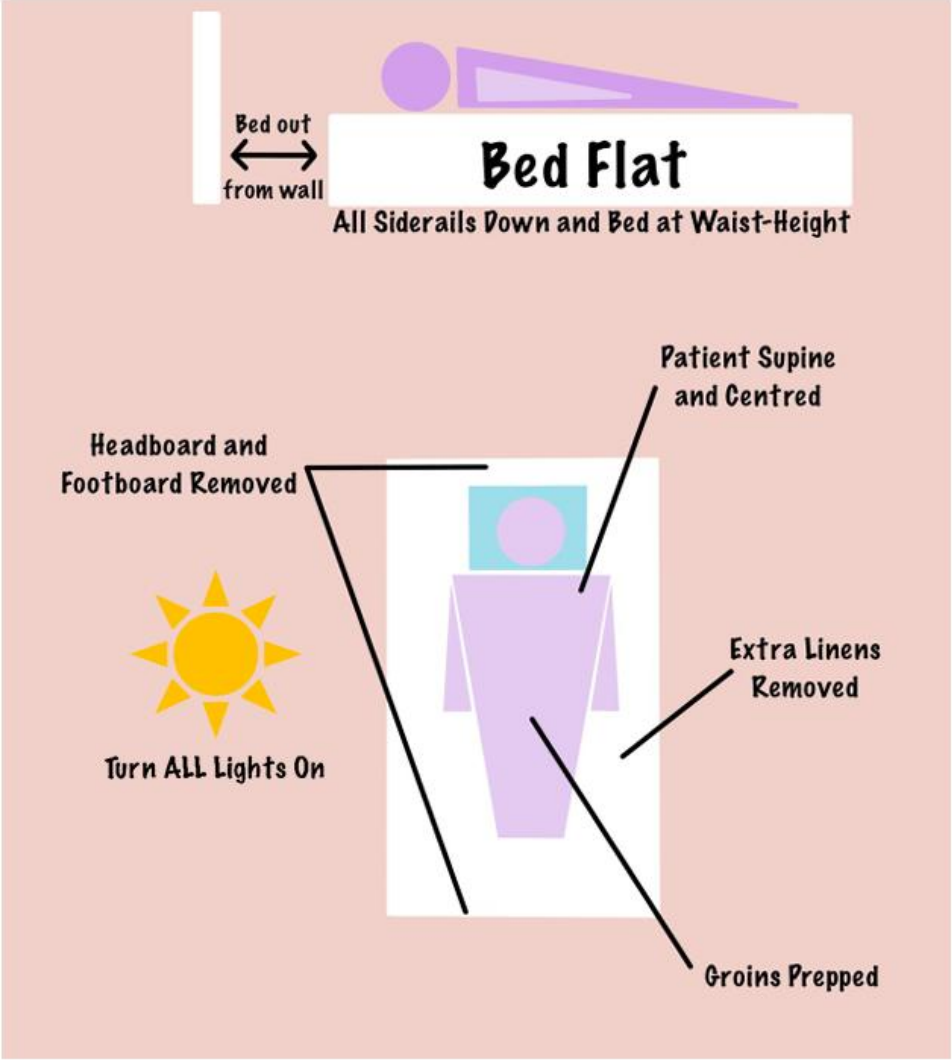
Patient Positioning Photo



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Ordering Blood Products

****ENSURE BLOOD PRODUCT ADMINISTRATION CHARTING IS COMPLETED****

IF HGB LESS THAN 100:

1. Obtain order from cardiac surgeon or CCU attending.
2. Verify that you have selected the correct patient before entering orders.
3. Order up 2 units of RBCs STAT:
    a. Begin to type '**red blood cells**' and double-click on this option.
    b. For product order page:
        i. Set 'Priority' to '**STAT**'
        ii. Number of units '**2**'
        iii. Fill out questionnaire information
        iv. For 'Clinical Indications' write '**ECMO initiation and Hgb less than 100**'
        v. For 'Administration Priority' put '**STAT**'
        vi. For 'Quantity to Administer (Units)' put '**2**'
        vii. For 'Infusion Rate' select the '**As fast as possible**' option – will need to administer as per cardiac surgeon's order for rate
    c. At the **TOP** of the order page, make sure to **select the check boxes** for 'TM product administration' and 'ABO/Rh and AB detection' (type and cross only needed if not already completed/specimen available in lab; check the "**ABO specimen in lab**" box if ABO already obtained).
        i. Under 'TM Administration':
            1. 'Priority' as '**STAT**'
            2. 'Quantity' as '**2**'
            3. 'Infusion Rate' select the '**As fast as possible**' option – will need to administer as per cardiac surgeon's order for rate
        ii. Under 'ABO/Rh and AB Detection':
            1. 'Priority' as '**STAT**'
    d. Place an order to request the blood product ('**TM request to dispense product**').
        i. For 'Priority' put '**STAT**'
        ii. For 'Product to Dispense' put '**red blood cells**'
        iii. For 'Quantity' put '**2**' and for 'UOM' put '**units**'
        iv. MAKE SURE TO CHECK OFF MULTIPLE IV LINES
    e. Call transfusion medicine (**7154**) and let them know you are ordering 2 units of RBCs STAT for emergent ECMO cannulation at the bedside in CCU. Ask for both to be sent up. These will usually be administered immediately following ECMO flow initiation, so have them ready to go. Write down the **code** given to you by TM for the tube system. Be mindful of the 30-minute limit to starting transfusion when receiving blood products.

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f. Prime blood tubing with NS and have ready to administer blood for shortly after cannulation is started.
g. Ask the cardiac surgeon when to spike the bags. Spike both bags simultaneously on the same blood tubing with one bag clamped and the other open. Run the pump at the **rate prescribed by the cardiac surgeon**. Monitor the line to ensure no air advances. Once the first bag is completed, unclamp the second bag and clamp the empty bag. Spike a flush where the first bag of blood was hung and run a flush of NS once the infusion is complete.
h. Monitor for signs of a transfusion reaction and ensure to document product administration, VS, etc., appropriately.

IF HBG GREATER THAN OR EQUAL TO 100:

1. Obtain order from cardiac surgeon or CCU attending.
2. Verify that you have selected the correct patient before entering orders.
3. Order up albumin 5% 500 mL STAT:
    a. Type '**albumin 5%**' and double-click on the option provided.
    b. Click on '**TM Administration**' at the top of the page. Put:
        i. 'Priority' as '**STAT**'
        ii. 'Quantity (mL)' as '**500**'
        iii. 'Infusion Rate' select the '**As fast as possible**' option – will need to administer as per cardiac surgeon's order for rate
        iv. Click '**Ok**' at the bottom of the page.
    c. For the product order page, put:
        i. 'Product Priority' as '**STAT**'
        ii. 'Quantity (mL)' as '**500**'
        iii. 'Administration Priority' as '**STAT**'
        iv. 'Quantity to Administer (mL)' as '**500**'
        v. 'Infusion Rate' select the '**As fast as possible**' option – will need to administer as per cardiac surgeon's order for rate (not to exceed 300 mL/hr)
        vi. Click '**Ok**' at the bottom of the page.
    d. Place an order to request the blood product ('**TM request to dispense product**').
        i. For 'Priority' put '**STAT**'
        ii. For 'Product to Dispense' put '**albumin 5%**'
        iii. For 'Quantity' put '**500**' and for 'UOM' put '**mL**'
    e. Call Transfusion Medicine (**7154**) and state that placing patient on ECMO in CCU and need albumin 5% 500 mL up STAT. Write down the **code** given to you by TM for the tube system.
    f. Have albumin at the bedside. Once cannulation is close to completion (wires inserted), prime IV tubing (vented) with albumin and program the IV pump to the

rate prescribed by the cardiac surgeon (not to exceed 300 mL/hr) or run via gravity with vented albumin tubing at the prescribed rate**.**

g. Monitor for signs of a transfusion reaction and ensure to document product administration, VS, etc., appropriately.

PLACING 2 UNITS OF RBCs ON HOLD:

1. Verify that you have selected the correct patient before entering orders.
2. Order 2 units as described above.
3. On the product ordering page:
   a. For 'Clinical Indications', write '**ECMO**'
   b. For 'Anticipated Usage Date' put **today's date**
   c. In 'Information to Lab' write '**Please place 2 units of RBCs on hold for 48 hours**.'

References/Additional Resources on Blood Product Administration:

Massive Transfusion in the Major Trauma Patient policy (HHN-CL-GC004)

Administration of Blood Products policy (HHN-CL-NU022)

https://profedu.blood.ca/en/transfusion/clinical-guide-transfusion

https://transfusionontario.org/en/

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ECMO Cannulation Procedure

OR Team is Present for Cannulation

1. The **primary nurse**, **recorder**, and **CCU attending physician** are to remain in the room. The **charge nurse** and **runner** are to stay outside of the room to run for supplies/make phone calls as needed.
2. The **CCU attending physician** remains responsible for managing the patient and a CODE BLUE (if applicable).
3. Titrate sedation, vasopressors, and inotropes as needed.
4. Monitor VS and patient status throughout the procedure. Bring concerns to the attention of the cannulating team.
5. Anticipate and assist with RSI as needed. Most patients going on ECMO will need to be intubated if not already intubated. Make sure **RT** is aware of the plan for ECMO/intubation.

CCU Assisting with Cannulation

1. The **scrub nurse** will need to scrub in with the cardiac surgeon. Major responsibilities include assisting with threading dilators on and off the guidewires and assisting with creating a water seal when connecting the cannulas to the ECMO circuit. Anticipate a percutaneous approach with the ultrasound in normal circumstances, or a cut-down procedure during cardiac arrest. The surgeon may or may not place distal perfusion catheter in CCU.
2. The **recorder** should be documenting actions and monitoring VS.
3. The **circulating nurse** finds supplies from the ECMO cart brought up by the perfusionist. **There is a list of supply locations on top of the cart**. Assist with positioning of equipment in room, etc.
4. The **med nurse** should be responsible for medication titration and administration.
5. The **CCU attending** should be present, if possible. They are to run the CODE BLUE if the patient arrests.
6. The **charge nurse** and **extra floor nurse** should be available to run for other supplies and make phone calls as needed.
7. Anticipate and assist with RSI as needed. Most patients going on ECMO will need to be intubated if not already intubated. Make sure **RT** is aware of the plan for ECMO/intubation.

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ECMO Post-Cannulation Checklist

Assessment Considerations

	Ensure that the cannulated groin is visible at all times. Be aware that blankets can kink the distal perfusion catheter. Ensure patient dignity as much as possible.
	Monitor VS and wean/titrate vasopressors and sedation/pain meds as needed. Ask the cardiac surgeon for specific orders if no sedation is running and needed (i.e., patient intubated, etc.). **Goal MAP is 65–70 mmHg.** Usual medications may include propofol, epinephrine, norepinephrine, and boluses of bicarb and calcium.
	NOTE that once ECMO is initiated, the initial arterial reading may have a flat waveform (**narrow pulse pressure**). If the pulse pressure does not widen (after pH correction, starting an inotrope, and/or administration of calcium), may need to be transferred to the cath lab or the OR for a left ventricular vent. Follow orders from the cardiac surgeon. **Goal pulse pressure is 15mmHg or more**. Check with the cardiac surgeon for specific pressure goals.

Interventions

	Provide supplies for/assist with central line and arterial line insertion to the other femoral site as needed (usually Cordis; may or may not place 3-lumen through this).
	Collect and send an ARTERIAL BLOOD GAS (ABG) once a peripheral arterial line is established.
	Anticipate the administration of up to 4 amps of IV sodium bicarbonate for pH correction if the ABG results come back while the patient is still in CCU.
	Anticipate the need for calcium administration as per the cardiac surgeon's order.
	If Hgb less than 100, anticipate administering 1-2 units of RBCs. If Hgb greater than 100, anticipate administering albumin 5% 500mL. Check with the cardiac surgeon for preference. Usually administered immediately after cannulation is finished.

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March 2026

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Transportation Preparation

	The ***charge nurse*** should call SICU (**6713**) before transfer to ensure the bed and staff are ready.
	Ensure patient is connected to a defib monitor **with pads on** AND the SpaceLabs portable monitor (ECG, SPO2, arterial BP, NIBP). Use the ETCO2 add-on to the SpaceLabs monitor or the EMMA portable monitor (on top of the med room fridge).
	Ensure the hallway is cleared of clutter to facilitate the transfer of the patient and equipment.
	Designate someone to hold the doors and the elevator. Only the **B-Tower** elevator fits ECMO patients. Use the **swipe card** from the 5th-floor code cart to call the elevator up. Tap the card to call the elevator (**porter swipe** near elevator button) and then tap the **code blue sensor** in the elevator and press the floor that you want. Hold the 'close door' button until the doors are closed. **MAKE SURE TO RETURN THE CARD TO THE CODE CART ON RETURN TO CCU.**
	Document VS from the procedure, titration or administration of medications, CODE BLUE notes as applicable, and any other interventions that the CCU team performed.

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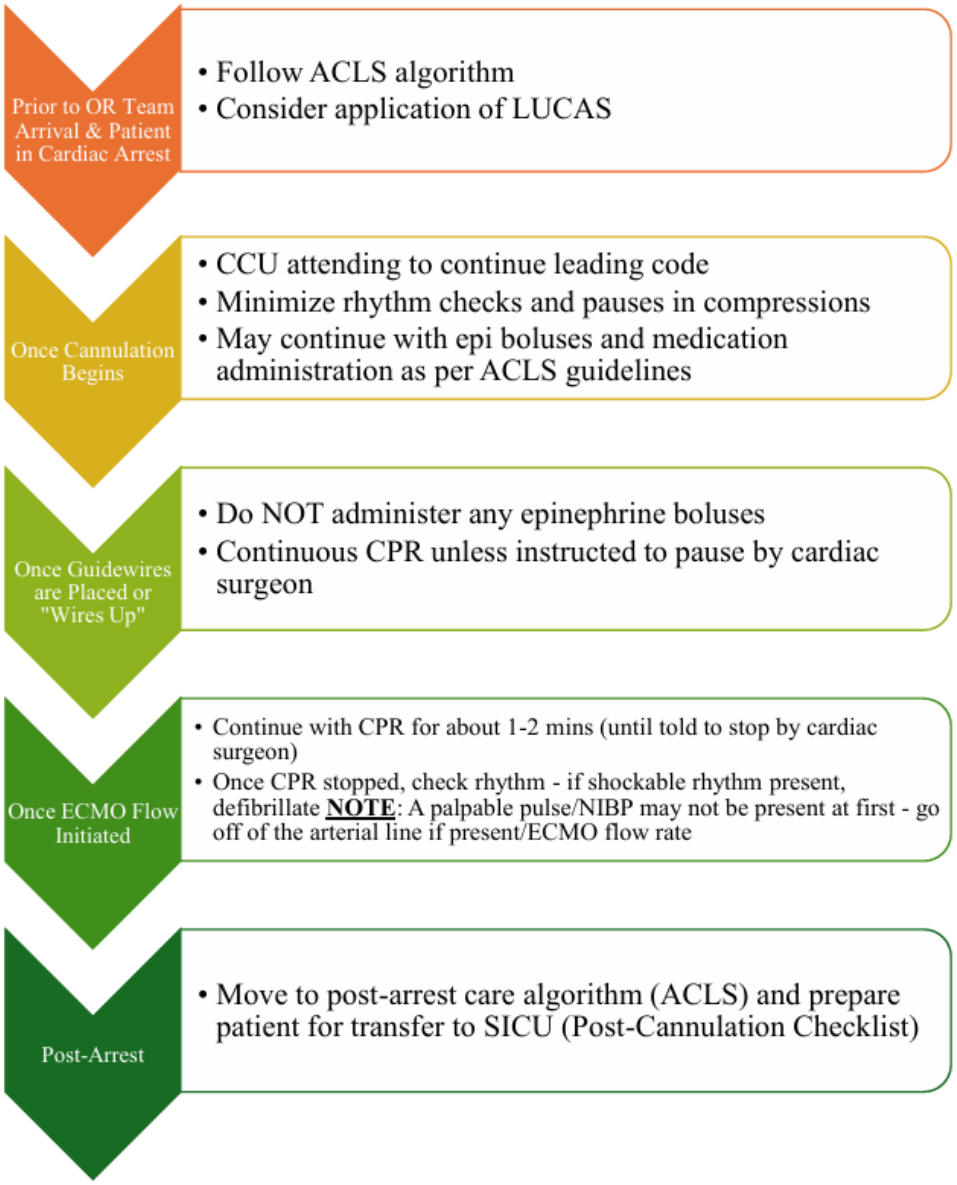
ECPR Algorithm



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Appendix D

Resource (PowerPoint Presentation)

3

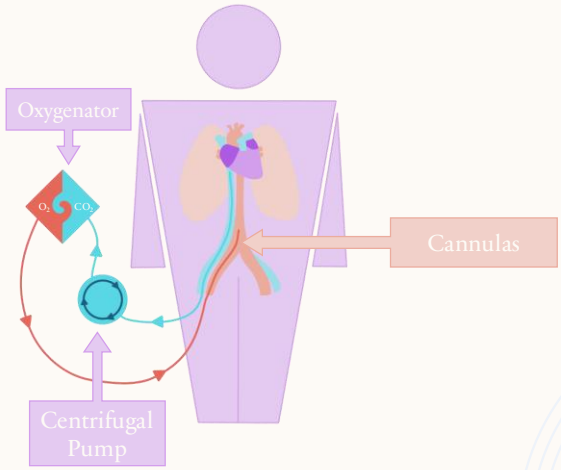
WHAT IS ECMO (ECLS)?

- Extracorporeal Membrane Oxygenation or Extracorporeal Life Support
- 2 Main Types:
  - Veno-venous ECMO (VV-ECMO)
  - Veno-arterial ECMO (VA-ECMO)
  - Subtypes
- VA-ECMO circuit consists of a venous cannula, centrifugal pump, oxygenator, heat exchanger, and arterial cannula
- ECPR

4

VA-ECMO CIRCUIT

- Heat Exchanger
- Distal Perfusion Catheter
- Console
- Gas Blender
- Flow Sensor Probe



5

INDICATIONS AND CONTRAINDICATIONS

Indications

- Cardiac arrest
- Cardiogenic shock
- Respiratory failure
- Severe thoracic trauma
- Sepsis
- Anaphylactic shock
- Refractory thyroid storm
- ANCA-associated vasculitis
- Obstructive shock
- Failure to wean from cardiopulmonary bypass
- Post-op graft failure

Contraindications

- End-stage organ failure/disease or multi-system organ failure with no option for transplant
- Uncontrolled hemorrhage
- Contraindication to anticoagulation
- Advanced age (>75 years)
- Untreated aortic dissection
- Aortic valve insufficiency/regurgitation
- Poor prognosis despite ECLS (e.g., prognostic scores; life expectancy < 1 year)
- Metastatic malignancy
- Severe neurological disease or injury with poor prognosis
- Morbid obesity
- Frail
- Outside of patient's goals of care
- High-setting mechanical ventilation for > 7 days
- Inadequate vascular access
- Inability to receive blood products

6

INCLUSION CRITERIA AT THE SJRH (RELATIVE)

- < 70 years of age (<65 for ECPR)
- Viable exit strategy
- Lack of end-stage co-morbidities
- Higher chance of survival if placed on ECMO
- Severity of injury to the patient's body

7

OTHER INCLUSION CRITERIA TO CONSIDER...

- Timing to ECLS < 6 hours from identification of CS, within 60 minutes of identifying refractory shock

In ECPR:

- Exhibiting signs of life during CPR
- Initial shockable rhythm or PEA
- Witnessed arrest with bystander CPR
- Temporary ROSC
- Higher baseline pH/ lower baseline lactate
- $ETCO_2 \geq 10$ mmHg during CPR
- PaO_2 levels
- Timing in ECPR < 5 minutes of no-flow time, < 60 minutes of low-flow time
- Reversible cause

8

POTENTIAL EXCLUSION CRITERIA

- > 75 years of age
- Frail
- Severely impaired baseline status
- Presence of life-limiting conditions
- Not within the patient's goals of care
- Presence of comorbidities
- Severe trauma
- Active and uncontrolled hemorrhage
- Aortic dissection
- Aortic valve incompetence
- Tension pneumothorax
- Severe pleural effusion
- Cardiac tamponade
- Papillary muscle rupture
- Interventricular septal rupture
- Free wall rupture
- Significant atheroma or calcification

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ADDITIONAL EXCLUSION CRITERIA IN ECPR

- Non-shockable initial rhythm
- Persistent signs of insufficient tissue perfusion (i.e., lactate ≥ 20 mmol/L, pH < 6.8, $ETCO_2$ < 10 mmHg)
- Unwitnessed arrest
- Prolonged no-flow and low-flow (> 60 minutes) times

10

POTENTIAL COMPLICATIONS

- Thromboembolic events
- Hemorrhagic events
- Major vessel dissection or perforation
- Pseudoaneurysm formation
- Nerve damage
- Transfixation of the inguinal ligament
- Accidental decannulation
- Cannula migration
- Limb ischemia
- Hypoperfusion with multi-system organ failure
- Systemic or localized infections
- Thoracic trauma
- Neurological injury
- Differential hypoxemia
- LV distension

OUTCOMES

30-45%

overall survival to discharge rate from ELSO global database

(Eckman et al., 2019)

- Limited strong evidence on the benefits of ECMO
- May improve survival and functional outcomes for some conditions
- Survival rate is widely variable across indications for use

QUESTIONS TO ASK

1. Will my patient likely benefit from ECMO (i.e., likelihood of recovery with vs. without ECMO)?
2. Is there a viable exit strategy?
3. Is this within my patient's goals of care?
4. Have all other strategies been exhausted?


CCU ECMO BIN
CHECKLISTS
PRE-CANNULATION

15

PRE-CANNULATION CHECKLIST: DELEGATION OF ROLES

- **Primary Nurse:** Stays in the room with the chart once the OR team arrives; provides information to the cannulating team; titrates and administers medications PRN; monitors VS and patient status
- **Secondary Nurse(s):** Recorder; monitor VS; assisting primary nurse with tasks PRN
- **Charge Nurse:** Stays just outside of the room; makes phone calls and runs for supplies PRN; **calls SICU** to update on ECMO initiation to ensure bed is available/staff ready for transfer; crowd control; **call RT**
- **Runner:** Stays just outside of the room; assists charge nurse with phone calls, running for supplies, and crowd control PRN
- **CCU Attending Physician:** Stays in the room, if possible; provides information to cannulating team; runs CODE BLUE, as applicable; manages ongoing resuscitation efforts
- **All Other Nursing Staff:** Stay out of the room unless assistance is needed, CODE BLUE is being run, or otherwise directed (preventing congestion in the room)

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PRE-CANNULATION CHECKLIST: PREP WORK

PLEASE NOTE that the prep work should all be done simultaneously to make sure the patient/room is ready for cannulation. Work together to tackle different parts of the checklist and check off what has been done as you go. Keep the checklist with the ECMO bin when not in use.

4 Key Areas to Prep:

- Prep of the Patient
- Prep of the Environment
- Prep of the Equipment
- Prep of Medications and Lines

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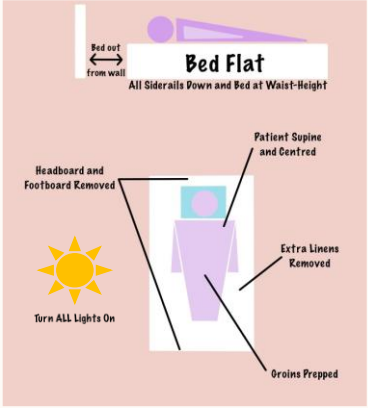
PREP OF PATIENT

- Positioning
  - Head and foot of bed flat
  - Patient in centre of bed, supine
  - Green Johnny shirt*
- Site prep (shave and hair debris removal)
  - The more the better – large areas (hand with fingers spread out)
  - HCG wash*
- Considerations when femoral central lines or IABP already in situ
  - Tear down dressings
  - Touch up shave prep if needed/ hair debris removal
  - Cover with sterile OR towels
- Intubation*



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PREP OF ENVIRONMENT

- Remove all equipment, furniture, belongings, and people from the room
- Clear hallway of clutter
- Bed out from the wall with headboard and footboard removed
- All side rails down and bed at waist-height
- All lights on

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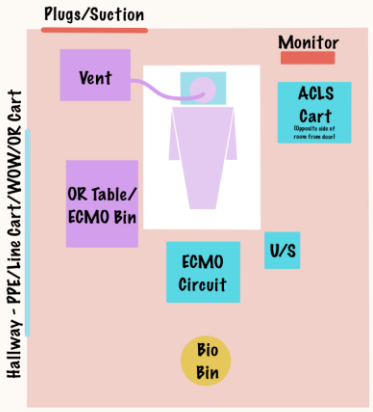
PREP OF EQUIPMENT



INSIDE OF ROOM:

- Bedside ultrasound in room with sterile probe covers
- Crash cart*
- Yellow biohazard bin
- ECMO bin (on ECMO OR table in med room)
- ECMO OR table at the end of the bed (in med room)
- LUCAS as needed – consider application before cannulation begins if patient coding

OUTSIDE OF ROOM:

- Line cart OUTSIDE of room
- Adequate PPE (routine and advanced precautions)
- WOW
- OR Supplies

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PREP OF LINES AND MEDS

- Obtain a group and cross (if not already done)
- Other bloodwork*
- Order up albumin 5% 500mL or 2 units of RBCs STAT
- Place 2 units of RBCs on hold
- Prime a blood administration line (albumin vs. RBCs)
- Have labelled syringe with heparin 5,000 units in the room
- Mix an epinephrine gtt and have it in the room
- Prime an arterial line set up; ensure appropriate cables are available in the room

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ORDERING BLOOD PRODUCTS

- Make sure to obtain an order from the cardiac surgeon
- If Hgb is less than 100, order 2 units of RBCs
- If Hgb is greater than or equal to 100, order albumin 5% 500 mL
- Place 2 units of RBCs on hold either way

- Have blood lines primed and ready for administration; usually administer shortly after ECMO flow is established
- Helps with ECMO flow rates

Additional Resources on Blood Product Administration:

- Massive Transfusion in the Major Trauma Patient policy (HHN-CL-GC004)
- Administration of Blood Products policy (HHN-CL-NU022)
- https://profedu.blood.ca/en/transfusion/clinical-guide-transfusion
- https://transfusionontario.org/en/

BEDSIDE CANNULATION

ECMO CANNULATION

OR Team is Present for Cannulation

- Primary nurse/secondary nurse and CCU MD in the room
- Charge RN and runner
- Titrate meds PRN
- Monitor patient
- RSI

CCU Assisting with Cannulation

- Scrub nurse
- Recorder to monitor VS and document everything
- Circulating nurse (supplies/OR cart)
- Nurse for medication titration and administration
- The CCU attending should be present, if possible
- Supplies runner
- Charge nurse to make phone calls or place orders

WHAT'S IN THE ECMO BIN?

SATELLITE ECMO BIN

BAG 1

- 3 BOUFFANT HATS
- 3 MASKS
- 3 6 ½ SENSICARE GLOVES

BAG 2

- 4 SOLUPREP LARGE SWAB STICKS (102.09) 6169835
- 2 DOUBLE-SIDED RAZORS (29795-100) 0015445
- 4 STICKY MITTS (FROM MOR)
- 1 DISPOSABLE #10 BLADE (73-0110) 0017217

BAG 3

- 1 SOFT FLEX PROBE COVER 4" X 24" (ON RT CART)
- 2 CLEAR 4-WAY STOPCOCK WITH MALE LUER (041210002A)
- 4 MICROPUNCTURE INTRODUCER SET (MPIS-501-SST)

1 OR INTERVENTIONAL PACK (DYNJ498048) 0015157

1 IMPERVIOUS FEMORAL ANGIOGRAPHY DRAPE (C29560) 0016908

1 U DRAPE IMPERVIOUS WITH SPLIT (DYNJP2499) 0015110

1 SATELLITE ECMO PAN

- 2 Gowns
- 3 Small Titanium Ligating Clips

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HELPFUL VIDEOS

- **ECPR Simulation:** Resuscitative ECMO insitu sim
- **Example of Syringe Water Seal:** VA ECMO Cannulation Simulation on RediStik ECMO Trainer
- **ECMO Cannulation Simulation:** ECMO cannulation

POST-CANNULATION

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ASSESSMENT CONSIDERATIONS

- Ensure that the cannulated groin is visible at all times. Blankets can kink distal perfusion catheter.
- Monitor VS and wean/titrate vasopressors/sedation as needed (orders**).
- NOTE about initial arterial reading

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POSSIBLE INTERVENTIONS POST-CANNULATION

- Assist with arterial line and central line insertion as needed
- Send an ABG once an arterial line is present
- Based on ABG results, anticipate administering the following meds (if patient still present in CCU):
  - Up to 4 amps of IV sodium bicarbonate
  - IV calcium
  - Albumin or RBCs (usually soon after cannulation)
- If Hgb <100, anticipate administering 1-2 units of RBCs. If Hgb > 100, anticipate administering albumin 5% 500mL. Check with the cardiac surgeon for preference.

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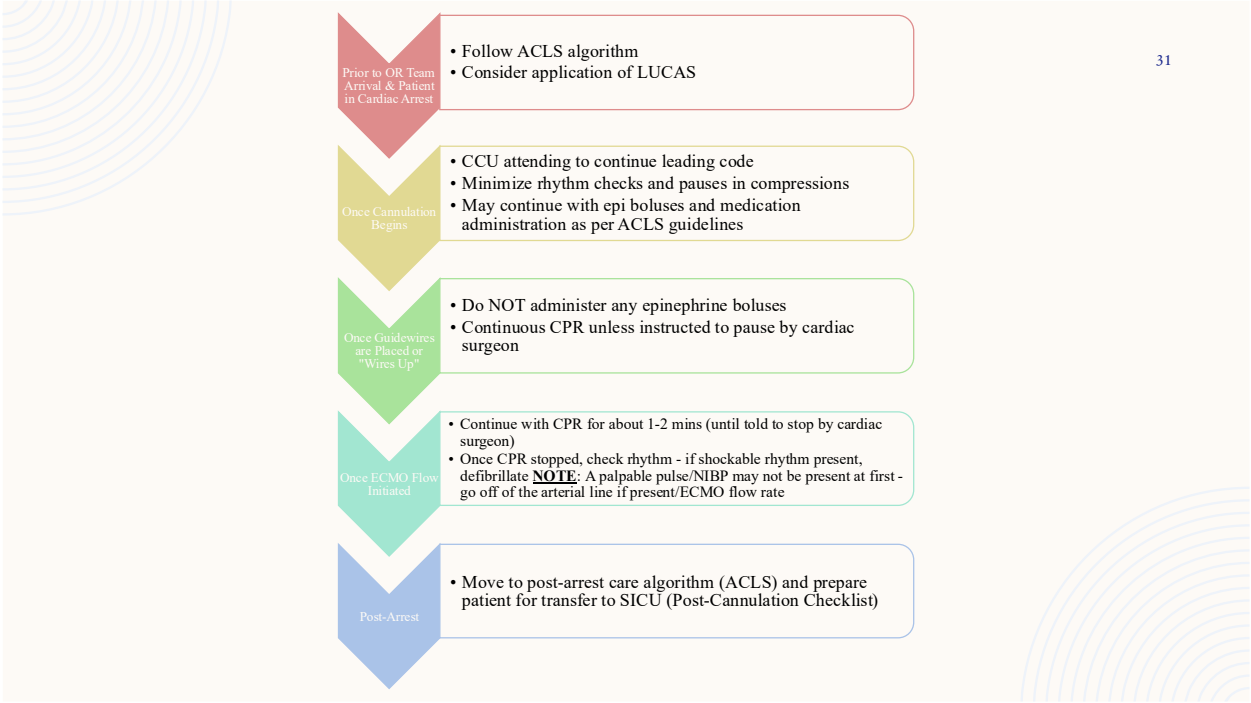
TRANSPORTATION CONSIDERATIONS

- The ***charge nurse*** should call SICU before transfer to ensure the bed and staff are ready.
- Ensure patient is connected to a defib monitor AND the SpaceLabs portable monitor (ECG, SPO2, arterial BP, NIBP); ETCO2 monitoring via EMMA or SpaceLabs add-on.
- Ensure the hallway is cleared of clutter to facilitate the transfer of the patient and equipment.
- Designate someone to hold the doors and the elevator. Use the swipe card on the crash cart. PLEASE RETURN.
- Document VS from the procedure, and titration or administration of medications, CODE BLUE notes as applicable, and any other interventions that the CCU team performed.

ECPR ALGORITHM



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