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REVIEW

Extracorporeal membrane oxygenation: unmet needs and perspectives

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Abstract

Extracorporeal Membrane Oxygenation (ECMO) has become an essential lifesaving intervention for individuals with severe cardiovascular and respiratory failure. Its application is expanding across several therapeutic contexts, surpassing conventional indications. The COVID-19 pandemic has significantly stressed worldwide health systems to manage acute respiratory failure. ECMO has been employed as a vital intervention, particularly for patients with severe COVID-19-induced acute respiratory distress syndrome (ARDS). ECMO is applicable throughout pregnancy. The principal indications for ECMO in pregnant women align with those in the general population. However, pregnancy complicates issues, necessitating consideration of both mother's and infant's well-being. Patients with systemic rheumatic diseases are prone to experience life-threatening complications. While a majority of these patients respond to immunosuppressive drugs, a small percentage suffer organ failure and may benefit from ECMO as a bridge to recovery. The article addresses coagulation therapies, highlighting the necessity of precise anticoagulation to avert both bleeding and thrombosis, particularly in patients requiring extended ECMO support. Additionally, the pharmacokinetics of antibiotics in ECMO patients are summarized, including the influence of the ECMO circuit on drug metabolism. Survey-based research offers valuable insights into ECMO use, procedures, and challenges. The paper evaluates current survey-based research and ECMO guidelines, highlighting clinical practice, training, and resource availability discrepancies across ECMO centers globally. Particular focus is placed on the rehabilitation requirements of ECMO survivors, acknowledging the importance of early mobilization and post-discharge care in improving long-term outcomes and quality of life.

Keywords Extracorporeal membrane oxygenation · ECMO treatment · COVID-19 · Pregnancy · Rheumatic diseases · Practice guideline · Surveys and questionnaires · Rehabilitation

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Introduction

Extracorporeal membrane oxygenation (ECMO) is an interim procedure employed to maintain lifesaving care for cardiovascular disease, lung and respiratory dysfunction, or both of them until the patient's organ(s) and structures have fully recovered or before alternative definitive therapeutic options can be implemented [1]. ECMO functions by diverting blood via an extracorporeal circuit, where it undergoes oxygenation and carbon dioxide removal from the patient's body before reintroducing it into the patient's bloodstream [2]. This technology serves as a conduit for facilitating recovery, organ transplantation, or making decisions on end-of-life care [3]. In recent decades, the utilization of ECMO has increased worldwide due to advances in technology and a greater acknowledgment of its capacity to enhance outcomes in patients with severe conditions [4].

Veno-venous or veno-arterial ECMO involves extracting deoxygenated blood from the veins, filtering it through a membrane oxygenator to eliminate carbon dioxide and increase oxygen level, and then returning the oxygenated blood to either the veins or arteries, depending on the specific technique. This procedure is made easier by a straightforward cannula structure, a blood pump, an oxygenator, and a device that exchanges heat [5]. Veno-venous ECMO is an option for cases of primary respiratory failure that do not respond to standard medical treatment and care and if mechanical ventilation fails to recover sufficiently [6]. Veno-arterial ECMO offers both carbon dioxide-oxygen exchange and mechanical circulatory assistance simultaneously with the heart's natural function. This is particularly beneficial in situations of isolated heart dysfunction or a combination of cardiac-pulmonary failure [7].

ECMO services can vary in their organization and execution across countries. South Korea and Japan have well-established ECMO centers that prioritize quick implementation and employ highly qualified multidisciplinary teams. South Korea has established an effective ECMO network with dedicated centers that aim to ensure prompt access [8–11]. ECMO services in the United States are mostly found in tertiary care centers and teaching hospitals affiliated with specialized ECMO programs. These programs offer comprehensive care, educational resources, and research prospects. These initiatives receive support from national and international guidelines that aim to standardize the utilization of ECMO and improve patient outcomes [12, 13].

The growing utilization of ECMO has sparked discussions over its cost-effectiveness and the ethical considerations of allocating resources, especially given the risks of death and morbidity associated with its application [14]. Maximizing benefits of ECMO technology requires addressing unmet demands and gaining a better knowledge of the factors that affect results.

Aim

This article overviews current practices, issues, and perspectives on ECMO in diverse medical settings. The article focuses on the administration of ECMO in critical care for patients with severe cardiovascular and respiratory failure and its application in specialized areas such as COVID-19, pregnancy, and rheumatic diseases. This article examines coagulation management and the pharmacokinetics of antibiotic therapies in ECMO patients. An additional objective is to provide an overview of the recommended ECMO-related protocols. The paper summarizes survey-based studies on the use of ECMO, focusing on differences in practice, resource allocation, and education in different ECMO centers and assesses the rehabilitation needs of ECMO patients.

Search strategy

While retrieving a list of papers related to the topic, Web of Science, Scopus, Medline/PubMed, and Directory of Open Access Journals (DOAJ) were considered. Search phrases were organized as follows: ''Extracorporeal Membrane Oxygenation'' or ''ECMO Treatment'' and ''COVID-19'' or ''Pregnancy'' or ''Rheumatic Diseases'' or ''Blood Coagulation'' or ''Antibiotics'' or ''Practice Guideline'' or ''Surveys and Questionnaires'' or ''Rehabilitation''. English papers published up until June 2024 were considered. While the authors did not specify a particular article type as an exclusion criterion, they assessed each article for its topical relevance. Additionally, authors scanned through the references of relevant papers and, where needed, consulted the corresponding scientific articles. Gasparyan et al.'s criteria served as the basis for creating and modifying the aforementioned search approach [15].

Extracorporeal membrane oxygenation during the COVID-19 pandemic

The COVID-19 pandemic has created a significant burden on global health systems in the treatment of severe respiratory failure. ECMO has been utilized as a critical approach, particularly for individuals with severe COVID-19-related acute respiratory distress syndrome (ARDS) [16, 17].

Although preliminary findings have indicated negative outcomes with the use of the ECMO approach [18], data from international registries and larger studies have shown promising results in COVID-19-related ARDS [19]. An extensive meta-analysis conducted during the early stages of the pandemic examined COVID-19 patients who underwent

ECMO support. The findings indicated that this particular group of patients had similar results to those with COVID-19-unrelated ARDS. This underscores the potential efficacy of ECMO in managing COVID-19 patients who are meticulously and correctly selected [20]. Research undertaken during the later phases of the pandemic has indicated a higher mortality rate among COVID-19 patients who received ECMO intervention. This can be attributed to changes in concurrent treatments, patient selection, increased overlapping bacterial pneumonia during immunosuppressive therapies, limited experience of health centers, and changing virus variants [21, 22].

The pandemic has also revealed the logistical and operational difficulties of using ECMO on a big scale. Hospitals encountered deficiencies in ECMO equipment, proficient personnel, and essential supplies. The high demand for ECMO during the pandemic has resulted in advances in resource allocation, such as establishing regional ECMO services and creating mobile ECMO teams to transfer patients to specialized centers [23]. Amid the pandemic, national-level coordination of ECMO initiatives was employed to enhance the effectiveness of standardizing ECMO eligibility and appropriately distributing resources. A regional network in Paris coordinated the care of hospitals to combine resources, standardize assessments for ECMO candidature, and increase ECMO capacity. This strategy was carried out to improve the efficient use of resources, simplify the workflow, enhance the management of patients before ECMO treatment, and improve gathering data [24, 25]. The Extracorporeal Life Support Organisation (ELSO) promotes the establishment of national ECMO connections and encourages the coordination of these organizations via a mapping system [26].

A dramatic increase in ARDS cases associated with COVID-19 has led to a corresponding surge in the need for ECMO support. The utilization of ECMO during the pandemic has been complicated by several factors, such as insufficient familiarity and understanding of ECMO-related outcomes, obstacles in conducting comprehensive studies during the pandemic, challenges in selecting patients during severe capacity limitations, ethical issues, and overwhelming pressure on healthcare systems. Nevertheless, utilizing ECMO in precisely selected cases has been linked to favorable results in managing COVID-19-induced ARDS [27].

Extracorporeal membrane oxygenation in pregnant patients

ECMO is now widely acknowledged as a lifesaving option for pregnant individuals who are suffering from serious cardiac or respiratory failure. Pregnancy poses distinct physiological obstacles, including heightened cardiac and respiratory demands that may worsen pre-existing diseases such as ARDS, cardiomyopathy, or serious infections like influenza and COVID-19 [28, 29]. The primary indications for ECMO in pregnants are similar to those in the general population. However, it is clear that pregnancy complicates matters since both maternal and infant well-being needs to be considered [30]. Planning a multidisciplinary team for this particular population is crucial, including several medical and surgical specialties and other healthcare experts [31].

The maternal survival rate for pregnant and postpartum patients who need ECMO has significantly increased. Survival rates for obstetric patients in ELSO registries currently surpass those of the general adult population [32]. Fetal survival data are also positive [33]. Both vaginal and cesarean delivery can be considered viable options for pregnants undergoing ECMO treatment. Decisions about pregnancy follow-up and gynecological procedures are tailored to each individual, considering factors involving stage of pregnancy, fetal lung advancement, pregnant's cardiopulmonary capacity, duration of time on ECMO, and any other existing health conditions [30].

It is important to carefully examine and manage severe anemia while providing ECMO procedures, as the amount of oxygen that the blood can carry relies on the quantity of hemoglobin. Thrombocytopenia frequently occurs during ECMO due to platelet activation caused by circuit parts, chronic inflammation, drugs, and related medical conditions. Furthermore, while pregnancy is a hypercoagulable state with an increase in clotting-related factors, von Willebrand factor, and fibrinogen, there is limited evidence to suggest that pregnancy raises the likelihood of oxygenator or ECMO system thrombosis [34].

ECMO has become an acceptable therapeutic choice for pregnant patients experiencing severe respiratory or cardiac failure, providing a potential pathway to recovery for both the mother and fetus. There is increasing evidence that ECMO is an essential tool in managing high-risk pregnancies that are complicated by life-threatening issues. Further research is warranted to enhance the criteria for selecting patients and to improve outcomes for both the mother and fetus.

Perspectives of extracorporeal membrane oxygenation in rheumatology

Patients with systemic autoimmune and inflammatory disorders are more likely to develop life-threatening consequences such as serious interstitial lung disease, pulmonary arterial hypertension, and cardiac or respiratory failure [35]. While many of these patients respond to immunosuppressive drugs, a fraction suffers from refractory organ failure

and may benefit from ECMO as a bridge to recovery [36, 37].

Bay et al. [37] presented one of the largest series (90 patients) on ECMO use and outcomes in rheumatic diseases. The vast majority of patients were admitted to the hospital for a worsening of their rheumatic disease, with just a quarter admitted for infection. Prior to hospitalization, the organs most frequently affected were the lungs, joints, skin, heart, and kidneys. Before being admitted to the intensive care unit, 47.8% of the patients consistently utilized corticosteroids, while 36.7% were on immunosuppressants. Intensive care unit mortality and in-hospital mortality rates were 48.9% and 51.1%, respectively. Emergency transplantation effectively cured nine patients with resistant cardiac ($n=5$) or pulmonary ($n=4$) failure.

Systemic lupus erythematosus (SLE) is a rheumatic disorder that may lead to severe and potentially life-threatening consequences, such as lupus myocarditis, extensive lung involvement, and thromboembolic events [38]. Leung et al. [39] presented a case of cardiogenic shock secondary to SLE and emphasized the positive effects of ECMO on disease management. Shi et al. [40] reported three hemodynamically unstable lupus myocarditis cases. ECMO support was provided to manage these cases. Gradual recovery of cardiac function was observed in all three patients after ECMO. Pacheco et al. [41] presented two patients with diffuse alveolar hemorrhage related to SLE. ECMO support was provided to manage both patients. The first patient died of hemodynamic failure caused by massive, severe bleeding and septic shock. The second patient successfully recovered and was removed from mechanical ventilation after a period of 10 days. During the follow-up of 1 year, the patient's condition remained stable, and he did not have any complications.

Zheng et al. [42] described 22 cases of acute lung injury associated with idiopathic inflammatory myopathies. All patients underwent ECMO. Eight patients died in the intensive care unit, six were successfully transitioned to recovery, and eight were properly transferred to transplantation. When comparing patients who were successfully supported till recovery and those who died, it was observed that the individuals who died were of older ages and had higher median comorbidity scores. Zulian et al. [43] presented a case of juvenile dermatomyositis with severe interstitial lung disease. Radiologic examination indicated diffuse interstitial pattern, alveolitis, pneumothorax, pneumomediastinum, and subcutaneous emphysema. The patient recovered with immunosuppressive therapy and ECMO support. Rubin et al. [44] reported a series of 9 cases on ECMO for myositis-associated rapidly progressive interstitial lung disease. One of the cases survived. Truong et al. [45] reported a patient with dermatomyositis with rapidly progressive interstitial pneumonia. The patient received ECMO support due to worsening respiratory failure. The patient died of hemorrhagic shock on the 14th day after ECMO.

Delvino et al. [46] documented two cases of diffuse alveolar hemorrhage caused by ANCA-associated vasculitis, which were successfully treated with ECMO support. ECMO provided a window of opportunity for lifesaving interventions in both patients. Alveolar hemorrhage did not worsen, and active bleeding ceased following the beginning of ECMO. Yusuff et al. [47] presented two patients without any prior vasculitis who experienced severe pulmonary hemorrhage caused by ANCA-positive vasculitis. The use of ECMO significantly assisted in their recovery. Matsumoto et al. [48] described two patients who experienced near-fatal respiratory failure due to pulmonary hemorrhage in ANCA-associated vasculitis. Following the use of ECMO, pulmonary hemorrhage diminished, and the patients were effectively withdrawn from ECMO.

ECMO support has been used in cases of mixed connective tissue disease-associated fulminant myocarditis [49], Kawasaki disease [50], and juvenile idiopathic arthritis [51]. Table 1 summarizes the main articles on ECMO support in rheumatic diseases.

Although case reports and small studies have described the use of ECMO in patients with rheumatic diseases, there is still a paucity of comprehensive clinical trials and recommendations specifically tailored to this group. Additional investigation is required to determine the most effective application of ECMO in rheumatology, such as identifying patients who are most likely to experience positive outcomes and developing strategies to minimize risks associated with autoimmune diseases and immunosuppressive treatments.

Coagulation-related issues

Managing coagulation in ECMO patients is crucial for preventing both thrombotic and bleeding disorders. The thrombotic process is induced by hypercoagulability, microdamage to the vessel wall, and reduction and stagnation of blood flow. The ECMO circuit comprises non-biological surfaces, areas with extremely high shear stress, and places where blood remains for extended periods. These effects increase the likelihood of blood clot development. Anticoagulant strategies may induce bleeding-related issues [52, 53]. Patients undergoing ECMO generally experience severe illness, which heightens their probability of experiencing bleeding. Bleeding most commonly occurs at the cannula location, gastrointestinal tract, lungs, and central nervous system [54].

Although there are various agents that can be used as anticoagulants in ECMO patients, heparin and direct thrombin inhibitors are the most commonly preferred

Table 1 Summary of the main articles related to ECMO support in rheumatic diseases

Author	Article type	Sex	Age (years)	Rheumatic disease	ECMO indication	Concomitant treatment	Prognosis
Bay et al. [37]	Retrospective study	Ninety patients (male/female ratio: 0.5)	41.6 ± 15.2	Consisting of SRDs	69 patients flare related issues and 21 patients infection-related issues.	Corticosteroids and immunosuppressant(s)	ICU mortality and in-hospital mortality rates were 48.9% and 51.1%, respectively.
Leung et al. [39]	Case report	Female	24	SLE	Cardiac failure and cardiogenic shock	IV methylprednisolone (25O mg)	After ECMO, her condition stabilised.
Shi et al. [40]	Case report (3 cases)	Case 1: Female Case 2: Female Case 3: Female	Case 1: 43 Case 2: 32 Case 3: 22	SLE	Cardiac insufficiency and cardiogenic shock	Dexamethasone (case 1), 500 mg of methylprednisolone (case 2), and methylprednisolone (1 g/2 days) (case 3)	Recovery of cardiac function was observed in three patients. Case 2 died due to pulmonary infection.
Pacheco et al. [41]	Case report (2 cases)	Case 1: Female Case 2: Male	Case 1: 33 Case 2: 36	SLE	Severe respiratory failure	Pulse corticosteroids and intravenous cyclophosphamide (case 1), Pulse intravenous corticosteroids and cyclophosphamide (case 2)	Case 1died and case 2 recovered.
Zheng et al. [42]	Case series (22 cases)	11 female and 11 male	47 ± 12	Idiopathic inflammatory myopathies	Respiratory failure	Corticosteroids, immunosuppressor(s), and plasmapheresis	Eight patients died, six were successfully transitioned to recovery, and eight were transferred to transplantation.
Zulian et al. [43]	Case report	Female	3	Juvenile dermatomyositis	Severe interstitial lung disease and respiratory failure	Metylpredisolone (30 mg/kg), prednisone (2 mg/kg), and cyclophosphamide (2 mg/kg)	Patient recovered.
Rubin et al. [44]	Case series (9 cases)	5 female and 4 male	52.2 ± 10	Myositis	Rapidly progressive interstitial lung disease	Seven patients received triple immunosuppressive therapy with pulse-dosed steroids, rituximab, and IV immunoglobulins. Patient 2 received mycophenolate mofetil, and patients 3 and 5 also received cyclophosphamide.	One patient was discharged without any sequelae.
Truong et al. [45]	Case report	Male	51	Dermatomyositis	Acute respiratory distress syndrome	Pulse dose solumedrol, cyclophosphamide, and cyclosporine	Patient died of hemorrhagic shock on the 14th day after ECMO.
Delvino et al. [46]	Case report (2 cases)	Case 1:Female Case 2: Male	Case 1: 45 Case 2: 45	ANCA-associated vasculitis	Acute respiratory failure, massive alveolar haemorrhage	Methylprednisolone pulses (1 g intravenously/day on 3 consecutive days), plasma exchange, and cyclophosphamide pulses (case 1). Methylprednisolone pulse therapy (1 g intravenously/day on 3 consecutive days), followed by rescue therapy with rituximab (375 mg/m2/ week on 4 consecutive weeks) (case 2).	The general condition improved.
Yusuff et al. [47]	Case report (2 cases)	Case 1: Female Case 2: Male	Case 1: 23 Case 2: 27	ANCA-associated vasculitis	Pulmonary capillaritis complicated by diffuse alveolar hemorrhage	IV methylprednisolone, 1 g daily for 3 days (case 1); pulsed IV methylprednisolone followed by daily hydrocortisone dosed at 50 mg IV four times a day, plasma exchange followed by rituximab and IV immunoglobulin (case 2).	Clinical improvement was achieved.

Table 1 (continued)

Author	Article type	Sex	Age (years)	Rheumatic disease	ECMO indication	Concomitant treatment	Prognosis
Matsumoto et al. [48]	Case report (2 cases)	Case 1: Female Case 2: Male	Case 1: 19 Case 2: 29	ANCA-associated vasculitis	Respiratory failure	Methylprednisolone pulse theray (250 mg/day|3 days) combined with plasma exchange was instituted, followed by oral cyclophosphamide (case 1); The Methylprednisolone pulse therapy (1000 mg/day|3 days), plasma exchange and intravenous cyclophosphamide	Clinical improvement was achieved.
Hamana et al. [49]	Case report	Female	22	Mixed connective tissue disease	Fulminant myocarditis	Steroid pulse therapy (methylprednisolone, one1000 mg/day), continued with prednisolone (100 mg/day) and intravenous cyclophosphamide (1000 mg)	Patient recovered.
Cohen et al. [50]	Case report	Male	2	Kawasaki disease	Respiratory and circulatory failure	IL-1RA was administered (anakinra once daily, 1 mg/kg subcutaneously). IVIG with low-dose prednisone was used.	Beneficial effects reported.
Yang et al. [51]	Case report	Male	14	Juvenile idiopathic arthritis	Macrophage activation syndrome, respiratory and circulatory failure	Pulse methylprednisolone therapy, followed by a maintenance dosage of 10 mg/kg/day	Patient recovered.

SRDs: Systemic rheumatic diseases; ICU: Intensive care unit; SLE: Systemic lupus erythematosus; ECMO: Extracorporeal membrane oxygenation

agents [52]. Unfractionated heparin is the most frequently employed anticoagulant due to its affordable price, titratability, and ease of reversal. Heparin suppresses thrombin by attaching to the antithrombin. Antithrombin has limited anticoagulant action; however, when coupled with heparin, its anticoagulant capacity rises dramatically [55]. Heparin utilization is linked to immune-mediated adverse effects referred to as heparin-induced thrombocytopenia. This condition is characterized by paradoxical prothrombotic status and decrease in platelet count [56]. Direct thrombin inhibitors are a class of anticoagulants that specifically attach to the active sites on thrombin. In addition, they offer higher reliability and predictability in preventing blood clotting as they are not bound to other proteins in the circulatory system. Furthermore, they do not stimulate heparin-induced thrombocytopenia. Their main constraint is the absence of a pharmaceutical antidote [57].

There are no consensus regimens for ECMO patients regarding anticoagulation procedures and monitoring approaches. According to a survey-based study covering ECMO facilities, the most frequently utilized anticoagulant is unfractionated heparin, titrated based on activated clotting time, activated partial thromboplastin time, or anti-Xa test outcomes. Because of the variability in practice, it is advised that each ECMO center develop the most beneficial algorithm for its needs [58].

Antibiotic therapies

ECMO is frequently employed in critically ill patients requiring antibiotics due to their susceptibility to infection resulting from their underlying medical conditions, invasive procedures, and extended hospitalization. ECMO therapy enhances vulnerability to infections, including bloodstream infections, ventilator-associated pneumonia, and cannula site infections. Many ECMO patients are immunocompromised, either as a result of the severe disease or due to other underlying disorders. In addition, certain individuals may be taking immunosuppressive drugs, which further weaken their immune system. The interplay between ECMO and antibiotic therapies poses distinct obstacles that necessitate meticulous deliberation, including diverse pharmacokinetics, dosage approaches, and concerns regarding antibiotic resistance [59, 60].

Several circuit characteristics may modify pharmacokinetics. These occurrences are contingent upon the characteristics of the drug, the type of circuit, and the formation of cylinders and biofilms. The ECMO circuit possesses a substantial surface area that may trap medications, while the coatings and components of the circuit itself diminish the bioavailability of antimicrobial substances [61]. The ECMO circuit's substantial volume augments the distribution volume. The dilution effect may decrease the plasma concentrations of certain antibiotics, resulting in subtherapeutic

levels and ultimately leading to unsuccessful treatment [60, 62]. ECMO may affect the functioning of the kidneys and liver, both of which play a crucial role in the elimination of drugs. Renal and liver failure, prevalent among critically ill patients undergoing ECMO, may necessitate adjustments in antibiotic dose or intervals. However, individuals who have hyperdynamic circulation may show an increase in the rate at which the drug is eliminated from their body, which may necessitate a dose increase [63, 64].

The connection between ECMO and antibiotic treatment necessitates a specialized strategy due to changes in medication absorption, distribution, metabolism, excretion, heightened susceptibility to infections, and possibility of encountering multidrug-resistant pathogens.

Practice guidelines on extracorporeal membrane oxygenation

Organizations like ELSO have created extensive practice guidelines to standardize ECMO use and enhance patient outcomes (https://www.elso.org/ecmo-resources/elso-ecmo-guidelines.aspx). These guidelines include both the technical and clinical aspects of ECMO support, with evidence-based recommendations for commencement, treatment, and termination. The recommendations emphasize multidisciplinary teamwork, patient selection, and strict management measures to maximize safety and efficacy. ELSO has recommendations for general and specific patient groups:

- *ELSO General Guidelines for all Extracorporeal Life Support (ECLS) Cases* (https://www.elso.org/portals/0/elso%20guidelines%20general%20all%20ecls%20version%201_4.pdf).
- *ELSO Guidelines for Neonatal Respiratory Failure* [65].
- *ELSO Guideline for Adult Respiratory Failure Managed with Venovenous ECMO* [66].
- *ELSO Guidelines for Pediatric Respiratory Failure* [67].
- *Extracorporeal Cardiopulmonary Resuscitation in Adults. Interim Guideline Consensus Statement From the ELSO* [68].
- *Pediatric Extracorporeal Cardiopulmonary Resuscitation ELSO Guidelines* [69].
- *Guidelines for Pediatric Cardiac Failure* [70].
- *ELSO Interim Guidelines for Venoarterial Extracorporeal Membrane Oxygenation in Adult Cardiac Patients* [71].
- *ELSO Guidelines for Adult and Pediatric Extracorporeal Membrane Oxygenation Circuits* [72].
- *Guidelines for ECMO in COVID-19* [73].

Patient selection is crucial in determining ECMO results, and the ELSO guidelines include extensive criteria to help with decision-making. When conventional approaches fail, ECMO is typically considered in patients with potentially reversible cardiac or respiratory failure. The ELSO recommendations also include the use of ECMO in pediatric groups [67, 69, 72] and certain adult groups, such as those suffering from respiratory failure due to COVID-19 [73].

The ELSO guidelines highlight that the effectiveness of ECMO treatment relies on thorough supervision, particularly regarding hemodynamics, oxygenation, ventilation, and anticoagulation. Weaning off ECMO should be considered when the patient's lung or cardiac function improves, as demonstrated by normal blood gas levels, better echocardiographic parameters, or a reduction in the requirement for mechanical ventilation. The ELSO guidelines recommend employing lower ECMO flows to assess the patient's capacity to maintain appropriate oxygenation and perfusion.

The ELSO practice guidelines are an essential tool for healthcare professionals involved in managing ECMO. These guidelines include thorough and evidence-based recommendations on patient selection, treatment strategies, and safety precautions. By following these instructions, ECMO centers may enhance patient survival rates, minimize challenges, and deliver better care for critically ill patients.

Survey-based studies on extracorporeal membrane oxygenation

Survey-based studies provide useful insights into the use, methodologies, and difficulties related to ECMO in various institutions and countries. These investigations are valuable in uncovering trends, gaps, practice variations, and areas requiring more standardization or research [74].

Sharma et al. [75] performed a cross-sectional nationwide survey of adult intensive care education courses in the United States to ascertain the preferences of intensivists on the use of various treatments for severe ARDS, including the implementation of ECMO. Eighty percent of participants stated that ECMO is available at their institution. A large number of participants (83%) expressed their willingness to explore ECMO as a treatment option for patients who did not respond to appropriate mechanical ventilation. Additionally, a substantial percentage (60%) stated that ECMO could assist in implementing lung protective ventilation. Approximately 62% pointed to the lack of knowledge of ECMO and prioritized targeted ECMO training throughout their education.

Abrams et al. [76] conducted a multi-country study with 531 physicians; elderly age (46.9%), additional organ dysfunction (37.7%), and extended period of ventilatory

support (35.1%) were the three major factors determined by the cohort that would restrict ECMO use.

Broman et al. [77] surveyed to investigate the organizational aspects of inter-hospital ECMO transport care in experienced medical centers. This survey involved fifteen mobile ECMO centers from nine different countries. Seven of them functioned using the "Hub-and-Spoke" concept. The team included three to nine individuals, with every center having at least one ECMO specialist. However, 69% of the teams included intensivists, and 50% included surgeons. The decision to commence ECMO was made collaboratively by all centers involved and was made directly at the patient's bedside in the referral hospital.

Bembea et al. [78] examined anticoagulants approaches during ECMO treatment. Of 117 responders, 84 (72%) stated that their institution had a documented institutional ECMO procedure for anticoagulation. Sixty-nine respondents (59%) stated that they utilized heparin-bonded circuits. All centers employed unfractionated heparin. Merely 8% indicated the use of other anticoagula.

Patel et al. [79] examined the implementation of ECMO education and certification for ECMO professionals worldwide. ECMO education was provided at 221 (92%) ECMO centers, and credentialing was implemented at 101 (42%) centers.

Milewski et al. [80] evaluated the ECMO implementation during the COVID-19 pandemic. During the pandemic, the proportion of high-volume ECMO operations (exceeding 20 patients annually) increased. More organizations established criteria for allocating resources, and various initiatives developed sharing partnerships.

Survey-based studies yield important insights into the practical implementation of ECMO support, highlighting critical trends, challenges, and avenues for enhancement. These surveys underscore the need for standardization, improved resource allocation, and continuous research to optimize patient outcomes.

Rehabilitation of extracorporeal membrane oxygenation patients

Rehabilitation is an essential aspect of the treatment strategy for patients on ECMO support. These patients frequently encounter substantial physical, cognitive, and mental challenges following ECMO care, attributable to the severity of their underlying condition, immobilization, and complications. Timely and structured rehabilitation is essential for enhancing recovery outcomes, reinstating functional independence, and improving quality of life. Rehabilitation approaches are comprehensive, encompassing physical, occupational, and psychological therapy customized to the specific requirements of ECMO survivors [81, 82].

One of the main objectives is to begin mobilization as soon as feasible, preferably during ECMO. Early mobilization can help relieve profound muscular weakness and deconditioning. However, early mobilization necessitates careful coordination because of the patient's complicated state and the hazards connected with cannulation and ECMO circuits [83]. A systematic review indicated that while active mobilization and rehabilitation did not influence short- or long-term mortality, it resulted in enhanced muscle strength at discharge from the intensive care unit, an increased probability of unassisted ambulation upon leaving the hospital, and a higher number of days lived outside the hospital at six months [84].

After decannulation and intensive care unit discharge, ECMO patients frequently experience severe muscular weakness, known as intensive care unit-acquired weakness, impacting both peripheral muscles and respiratory function. The rehabilitation program following intensive care unit release emphasizes the progressive restoration of strength, endurance, and overall physical function [85]. Respiratory muscle weakness is prevalent, particularly in ECMO patients on mechanical breathing. Pulmonary rehabilitation, encompassing breathing exercises, inspiratory muscle training, and lung secretion-clearing procedures, is crucial for enhancing respiratory function and facilitating the weaning of patients from oxygen supplementation [86].

Mortality in ECMO-supported patients with transplants is linked to the extent of organ failure; however, pre-transplant deconditioning is an important further contributor. Deconditioning, prevalent in critically ill individuals, is intensified in those requiring ECMO due to cannulation methods, immobilization, and anesthetic protocols [87]. Fuehner et al. [88] demonstrated enhanced survivability for individuals bridged to lung transplantation employing an "awake ECMO" technique compared to those treated with standard mechanical ventilation, highlighting the potential benefits of reducing sedation. In addition to reducing sedation, proactive early rehabilitation is the subsequent measure that might enhance outcomes for patients receiving ECMO as a bridge to lung transplantation [89].

Rehabilitation is essential for the recovery of ECMO patients. Early mobilization, structured rehabilitation programs, and long-term follow-up are crucial for enhancing results and assisting ECMO survivors in achieving functional independence. A multidisciplinary approach is necessary for achieving a comprehensive and effective rehabilitation process.

Conclusion

ECMO has become essential in managing severe cardiovascular and pulmonary conditions, providing vital support to patients who require life-saving intervention. Technological advances and improved knowledge of ECMO benefits have led to its widespread application in various medical specialties. The COVID-19 pandemic underlined the need for ECMO, particularly in treating severe respiratory failure, such as COVID-19-induced ARDS. Despite resource allocation and logistics issues, the pandemic demonstrated the benefits of regional ECMO services and national coordination in enhancing patient outcomes.

The use of ECMO in rheumatology has shown promise, notably in the treatment of severe organ failure in patients with autoimmune and inflammatory disorders. While clinical research and recommendations for this group remain limited, emerging data suggests that ECMO can serve as a bridge to recovery in certain situations of refractory disease.

ECMO requires a structured rehabilitation approach to tackle physical, psychological, and cognitive impairments. Early mobilization, extensive rehabilitation, and prolonged follow-up are essential for enhancing functional results and quality of life in ECMO survivors.

Continuous research, multidisciplinary interaction, and standardized ECMO processes are crucial for enhancing patient care and results in various clinical contexts.

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Declarations

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Healthcare professionals' perceptions of nurses' qualifications and roles in extracorporeal membrane oxygenation: an online cross-sectional survey

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Abstract

Extracorporeal membrane oxygenation (ECMO) is a critical life-support system necessitating multidisciplinary management. This cross-sectional study assessed healthcare professionals' views on the roles, qualifications, and training requirements of ECMO nurses. An online cross-sectional survey was administered using SurveyMonkey from February 17 to May 10, 2025. Health professionals from various fields and countries were invited using social media platforms. The questionnaire was created following ECMO guidelines and evaluated by five experts. It encompassed areas including fundamental ECMO knowledge, nursing qualifications, educational requirements, practice obstacles, and demographic variables. The survey included Likert-style, multiple-choice, binary, and open-ended items. A total of 93 healthcare professionals from 12 countries responded. Most participants were nurses ($n=35$; 37.6%) or ECMO specialist nurses ($n=21$, 22.6%). Thirty-two (34.4%) respondents mentioned that their institutions provided ECMO-specific nursing training. Participants identified complication prevention as the top training priority ($n=72$, 77.4%). Essential nursing competencies included monitoring for device integrity ($n=88$, 94.6%) and signs of hypoperfusion ($n=84$, 90.3%). Primary barriers were inadequate training ($n=42$, 45.2%), shortage of ECMO nurses ($n=40$, 43.0%), and excessive workload ($n=40$, 43%). The majority of participants highlighted the necessity of enhancing educational infrastructure as the primary strategy to improve ECMO nurse involvement ($n=70$, 75.3%). Nurses are essential to ECMO care. Emphasizing hands-on training, implementing standardized competence frameworks, and tackling structural obstacles are crucial for enhancing ECMO nursing practices. Given that some rheumatic disorders require ECMO due to severe autoimmune and multiorgan issues, the evolution of ECMO nursing should include a rheumatology-focused approach. Integrating rheumatology-specific understanding into ECMO nurses' education and practice is critical for improving outcomes in patients on ECMO.

Keywords Extracorporeal membrane oxygenation · Standard of care · Education · Nurses · Nursing · Surveys and questionnaires

Introduction

Nursing is a rapidly developing profession that delivers services based on available evidence, aimed at preventing diseases, promoting health, and enhancing quality of life [1]. Nurses are essential figures in modern health systems, actively engaged in decision-making and patient education [2]. In high-risk clinical environments, such as intensive care units, the significance and scope of nursing practices are increasing [3].

Extracorporeal membrane oxygenation (ECMO) is a specialized life-support procedure used to save the lives of individuals with severe respiratory and/or circulatory failure [4]. The ECMO system, which provides temporary support for cardiac or pulmonary function, consists of components, including membrane oxygenator, pump, and heat exchanger [5]. ECMO, predominantly used in intensive care units,

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requires expertise and collaboration among skilled team members [6, 7].

Nurses play a multifaceted role in ECMO applications, necessitating a continuous balance between patient care and device management. The multifaceted duties include monitoring vital signs of ECMO-supported patients, timely identifying complications, assessing cannula sites, overseeing infection control, and providing psychosocial support [8–10]. The extent and assignment of these roles may differ among countries, institutions, and even clinics [11]. Given the increasing use of ECMO, it is essential to analyze experiences and perspectives in this domain to inform clinical guidance and policy formulation [12].

Rheumatic diseases (RDs) are a substantial but neglected category requiring ECMO due to multiorgan involvement induced by systemic inflammation and autoimmune processes. Acute pulmonary hemorrhage, severe respiratory failure, pulmonary hypertension, cardiogenic shock, or fulminant myocarditis in RDs such as systemic lupus erythematosus, ANCA-associated vasculitis, antiphospholipid syndrome, systemic sclerosis, immune-mediated myocarditis, and myositis may necessitate ECMO support [13, 14]. Moreover, the immune dysregulation and disease activity inherent in RDs interact with immunological responses elicited by the ECMO circuit, including complement activation, cytokine release, thromboinflammatory processes, and hemolysis, therefore complicating therapeutic management [15]. The role of ECMO nurses transcends basic technical care; it encompasses an interdisciplinary responsibility that requires constant observation of immunological processes, autoimmune exacerbations, and challenges particular to RDs. The overlapping fields of rheumatology and critical care require reassessment of ECMO nursing in the rheumatological setting and the definition of competencies in this domain.

This study aims to thoroughly assess the extent of ECMO nurses' duties, educational needs, required contributions, and unmet needs. The survey was administered to healthcare professionals to obtain a comprehensive view on ECMO nursing. This comprehensive approach aims to examine nurses' roles in ECMO practice, identify training gaps, and contribute to the development of frameworks that promote professional development and growth.

Materials and methods

This cross-sectional online survey aimed to assess health professionals' perspectives on nurses' competence and roles in ECMO procedures. The primary requirement for participation in the survey was that participants were health professionals, which was verified through the acquisition of explicit consent from each participant. The survey included multifaceted questions regarding the participants' comprehension of ECMO, their professional backgrounds and experiences, their observations of nursing practices, and their perspectives in this area. Participants consented to use their responses for research puposes provided their identity would be kept confidential. SurveyMonkey.com, a user-friendly and widely favored online survey platform, was used to collect the survey data.

Questionnaire design

After reviewing contemporary literature on ECMO applications and nursing duties, the initial version of the questionnaire questions was drafted. The questionnaire was based on established clinical practice and global ECMO standards. Practice guidelines issued by the Extracorporeal Life Support Organization (ELSO) were primary references for content integrity and relevance (https://www.elso.org/ecmo-resources/elso-ecmo-guidelines.aspx).

The questionnaire questions were designed to assess health professionals' views on nurses' competency in ECMO. It was structured to incorporate multiple-choice, Likert-style, and open-ended questions to explore educational requirements, work allocations, team roles, and clinical obstacles in ECMO. The questions were constructed in an easy-to-understand and descriptive manner, particularly in terms of technical topics, to ensure that respondents could answer the questionnaire easily.

The content evaluation and revision were conducted to enhance the validity and consistency of the questionnaire, with input from five experts in the field. The experts evaluated the questionnaire items for conceptual consistency, linguistic clarity, and content validity, leading to specific suggestions for adjustments. A two-stage revision process was conducted following the content analysis. The initial revision encompassed modifications to both content and format to ensure the structural integrity of the questions. During the second stage, the questionnaire was refined towards its final version by evaluating the relevance of the suggested modifications.

A pilot test was conducted to evaluate the questionnaire prior to its implementation. Ten health professionals from different backgrounds were engaged through an online survey link and requested to complete the survey using the SurveyMonkey.com platform. The responses were evaluated to identify any technical issues. Furthermore, comprehensive feedback was gathered about the clarity of the questions, remarks on the statements, and overall views. The questionnairewas finalized after receiving final adjustments based on these evaluations.

The final version of the questionnaire is included as Appendix 1. The questionnaire is divided into 5 sections: basic knowledge of ECMO (3 questions); ECMO nurse experience/qualifications (6 questions); ECMO nurse education (10 questions); barriers and unmet needs in ECMO nursing (3 questions); socio-demographic information (10 questions). Overall, the questionnaire included 5 Likert-style, 23 multiple-choice, 3 binary, and one open-ended questions.

Participants had the opportunity to review and, if required, adjust their replies during the questionnaire completion process. Administering the questionnaire online allowed for the flexible rearrangement of questions, enabling responders to make revisions prior to finalizing their replies. Participants were prevented from modifying their replies once the questionnaire was finalized and sent through the system. This approach was adopted to ensure the reliability of the data and to prevent potential further interference. To eliminate incomplete forms from the data analysis, all questions were designated as "mandatory fields" in the application utilized on the SurveyMonkey platform. This method was regarded as a precautionary measure to protect the integrity of the data and ensure the reliability of statistical analyses.

Sampling

The convenience sampling approach was employed. Participation in the study was voluntary, and the survey link was disseminated across several online platforms, including those catering to a diverse array of healthcare professionals. The questionnaire's online accessibility facilitated participation from healthcare professionals across various institutions, overcoming geographical constraints. Filled questionnaires were collected from February 17, 2025 till May 10, 2025. Throughout this period, the survey link was disseminated via X (formerly Twitter), Facebook, and WhatsApp.

Confidentiality and integrity

The confidentiality and security of respondent data were guaranteed through the utilization of IP addresses and email information in this study. This identifying information was used to confirm the authenticity of each response and to prevent duplicate participation. This information was retained solely for technical verification; it was not matched with participants' identification data and was handled with confidentiality. The authors implemented requisite measures to ensure that all data remained anonymous and allowed the raw data to be evaluated solely in anonymized form. The data were structured to exclude any identifiable information and kept in secure databases. By responding to all questions and completing the questionnaire, respondents gave their agreement to publicize their anonymized answers.

This study was conducted and reported in accordance with widely publicized methodological recommendations for survey studies [16]. The local bioethics committee of South Kazakhstan Medical Academy approved the study protocol (protocol N1, May 25, 2024).

Statistical analysis

The analysis of the data was carried out using the Microsoft Excel software. The data were expressed as number (n), percentage (%) and median (minimum - maximum). Figures were created in Microsoft Excel. The qualitative data obtained from the open-ended question were classified and interpreted under categories using the content analysis method.

Results

Participant characteristics

Ninety-three healthcare professionals participated in the survey. Among them, 60 (64.5%) responders were females and 33 (35.5%) were males. The median age was 37 (20–61) years. The majority of respondents ($n=89$, 95.7%) indicated employment in urban healthcare settings. Participants were representative of 12 different countries. The largest subgroup originated from Kazakhstan ($n=62$, 66.7%), followed by the United States ($n=11$, 11.8%), India ($n=3$, 3.2%), Tajikistan ($n=3$, 3.2%), Jordan ($n=3$, 3.2%), Croatia ($n=3$, 3.2%), Italy ($n=2$, 2.2%), and the United Kingdom ($n=2$, 2.2%). Furthermore, one participant each (1.1%) originated from Australia, Mexico, the Philippines, and Spain (Fig. 1).

Participants mentioned a variety of professional positions. The job title most commonly stated was nurse ($n=35$, 37.6%), followed by ECMO specialist nurse ($n=21$, 22.6%), anesthesiologist ($n=9$, 9.7%), and perfusionist ($n=8$, 8.6%). Additional responsibilities comprised ECMO specialist physician ($n=4$, 4.3%), intensivist ($n=4$, 4.3%), cardiologist ($n=3$, 3.2%), cardiac surgeon ($n=3$, 3.2%), chief nurse officer, pulmonologist, and emergency physician (each $n=1$, 1.1%) (Fig. 2). Participants had a diverse range of academic backgrounds. The most common degree was Bachelor of Science ($n=37$, 39.8%), followed by College Degree in Nursing ($n=26$, 28%). A small percentage held Master of Science ($n=8$, 8.6%), Medical Doctor (MD) ($n=7$, 7.5%), and Doctor of Philosophy (PhD) degrees ($n=4$, 4.3%). Concerning institutional affiliation, 41 respondents (44.1%) indicated employment in private hospitals, 35

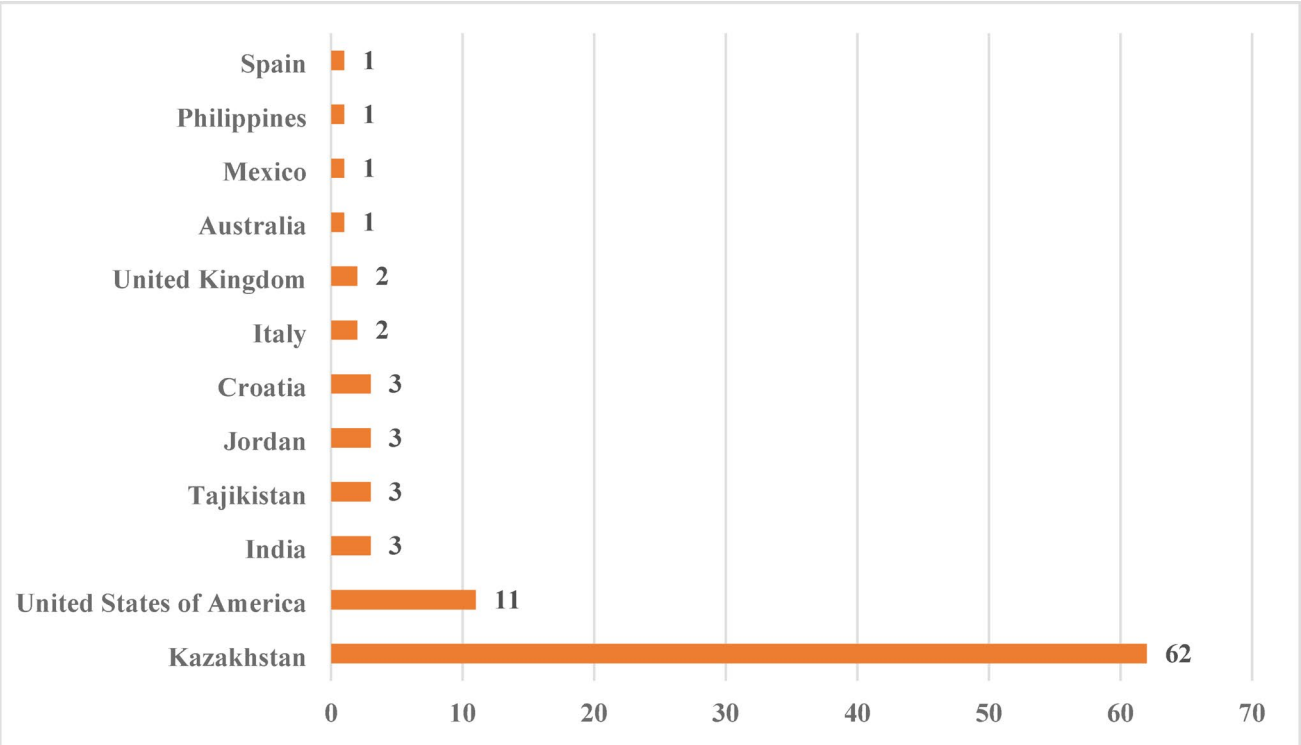

Fig. 1 Distribution of participants by country

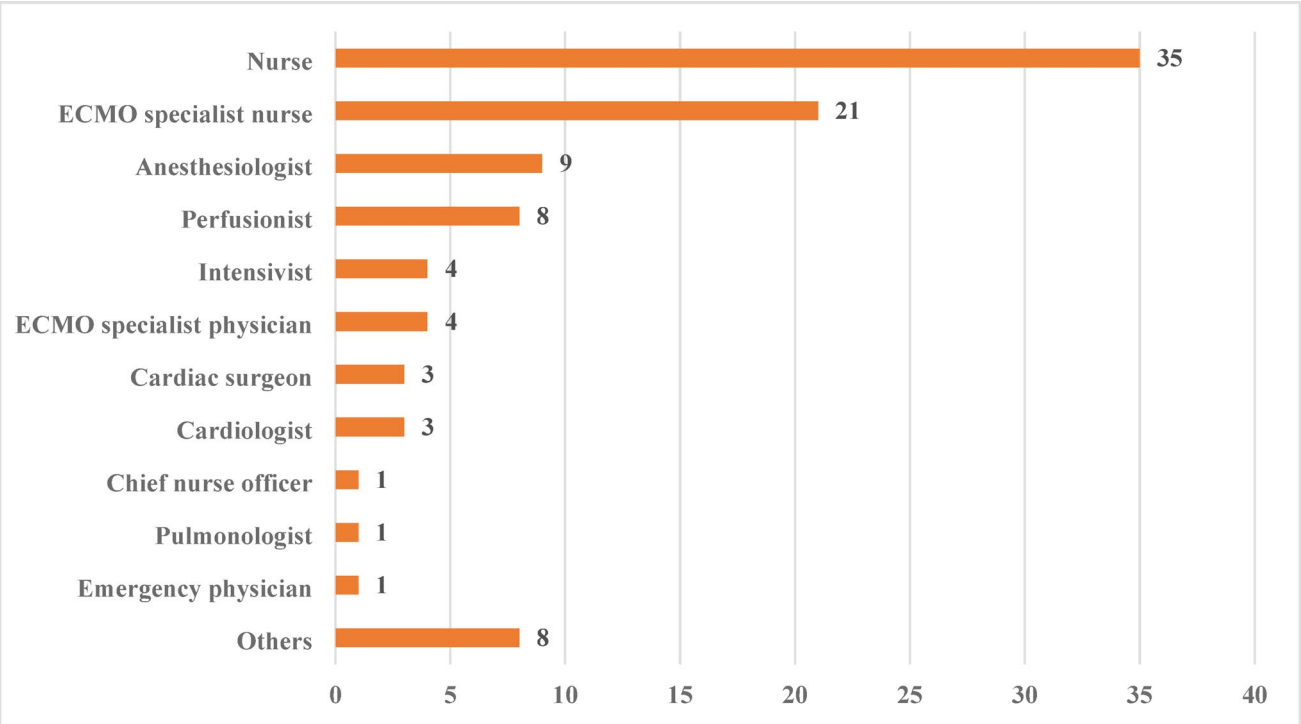

Fig. 2 Distribution of participants according to their professional titles. More than one option is possible

(37.6%) in public hospitals, and 16 (17.2%) in university-affiliated hospitals.

Professional experience and clinical involvement in ECMO

Participants indicated their experience in intensive care or emergency health care: 40 (43%) respondents had over 10 years of experience, 20 respondents (21.5%) 1 to 5 years, while 12 participants (12.9%) indicated 5 to 10 years of practice. Fifty-one (54.8%) respondents indicated that their medical organization had an ECMO unit, whereas 42 (45.2%) respondents reported that such a unit was not present. Considering ECMO case contact, 39 (41.9%) participants indicated that they do not handle ECMO patients yearly, whereas 26 (28%) manage 1–10 patients, 10 (10.7%) manage 10–20 patients, and 18 (19.4%) above 20 patients annually.

Perceptions about ECMO nursing roles and practice standards

Seventy-one (76.3%) participants reported familiarity with the Medical Subject Headings (MeSH) definition of ECMO. Forty-two (45.2%) respondents acknowledged familiarity with the Extracorporeal Life Support Organization (ELSO) guidelines, whilst 47 (50.5%) stated they were not. Furthermore, 4 (4.3%) respondents expressed uncertainty.

Participants were requested to evaluate their level of agreement with the statement "ECMO nurses play a central role in managing ECMO-supported patients," with 46 respondents (49.5%) agreeing and 23 (24.7%) strongly agreeing with it. Participants were requested to identify the professionals to be included in nursing teamwork within ECMO centers. The role most commonly mentioned was ECMO specialist nurse ($n=83$, 89.2%), followed by nurse perfusionist responsible for managing ECMO machines ($n=76$, 81.7%), and ECMO physiotherapist (nurse) for early mobilization of ECMO patients ($n=68$, 73.1%). Furthermore, 66 (71%) participants identified bedside nurses, while 63 (67.7%) respondents emphasized the necessity of a specialist for providing psychological support to ECMO patients and their families.

Participants were questioned to determine the optimal ECMO nurse-to-patient ratio for delivering effective nursing care. The primary choice among participants was a 1:1 ratio ($n=80$, 86%).

ECMO nurse training: educational infrastructure, content, and preferences

In response to the inquiry regarding the availability of ECMO-specific nurse training at their healthcare institutions, 32 (34.4%) participants confirmed its existence, while 59 (63.4%) indicated that such training is not provided at their workplace. Most respondents ($n=55$, 59.1%) preferred face-to-face courses, while 30 (32.3%) participants favored hybrid formats that integrate online and offline components. Only three (3.2%) participants preferred online-only training (Fig. 3). Regarding training venues, ECMO units within

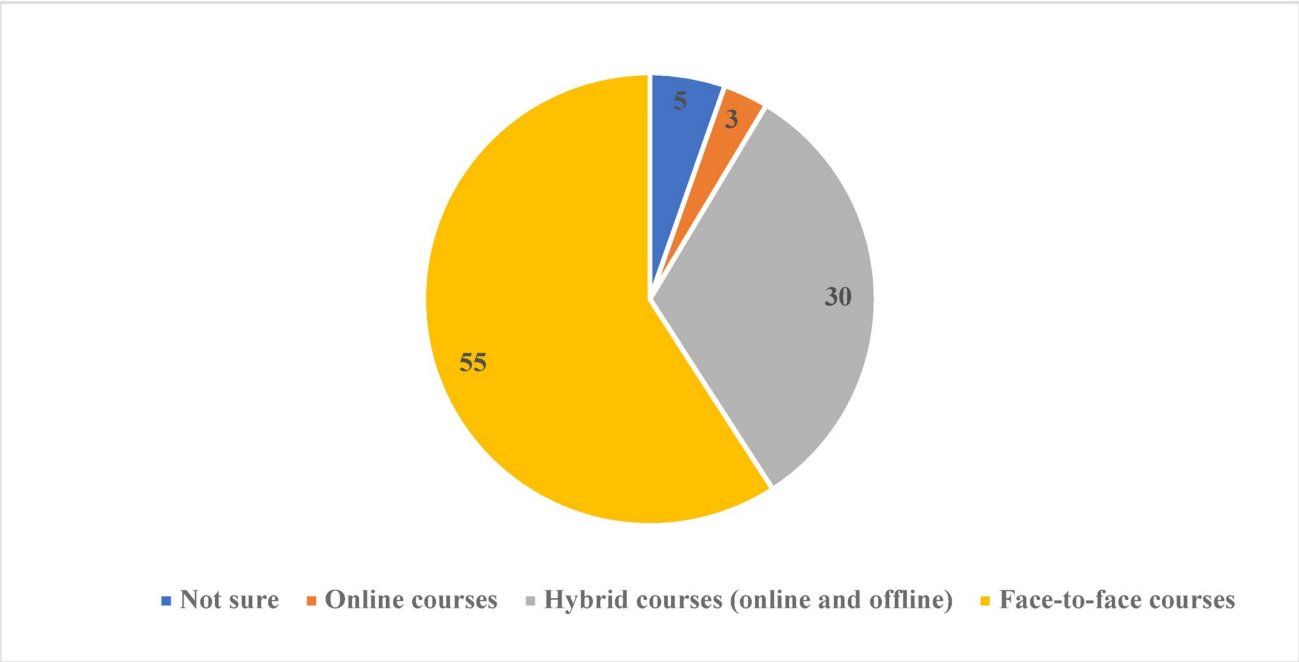

Fig. 3 Preference status of ECMO nurse education modes

participants' institutions were identified as the most appropriate locations ($n=41$, 44.1%), followed by prominent ECMO centers within their own country ($n=30$, 32.3%) and international ECMO centers ($n=16$, 17.2%). Furthermore, 6 (6.4%) participants expressed uncertainty regarding the ideal location for face-to-face training.

The majority of respondents ($n=50$, 53.8%) stated that ECMO nurses should participate in continuing professional development training annually, while a smaller proportion ($n=30$, 32.2%) suggested every six months. Smaller groups favored meetings every three months ($n=7$, 7.5%) or once in five years ($n=6$, 6.5%). When asked if only nurses who have completed ELSO-approved ECMO certification courses should be engaged in ECMO care, 27 participants (29%) agreed, 7 (7.6%) strongly agreed, and 31 (33.3%) were neutral. A sizable proportion disagreed ($n=23$, 24.7%) or strongly disagreed ($n=5$, 5.4%). Concerning the courses deemed most essential, 30 (32.3%) participants chose both American Association of Critical-Care Nurses (AACN) and ELSO training programs, 19 (20.4%) favored ELSO only, and 3 (3.2%) endorsed AACN alone. Furthermore, 8 (8.6%) individuals asserted that neither course was necessary, while 33 (35.5%) expressed uncertainty regarding the importance of the training options.

The most preferred previous expertise for nurses initiating ECMO training was former intensive care unit practice ($n=82$, 88.2%). Cardiothoracic departments ($n=30$, 32.3%), interventional cardiology ($n=18$, 19.4%), and pulmonology ($n=9$, 9.7%) were the other relevant backgrounds.

Participants identified critical content areas for ECMO nurse training. The predominant topic selected was the prevention of ECMO complications ($n=72$, 77.4%), followed by hemodynamic monitoring ($n=67$, 72%), early rehabilitation exercises ($n=65$, 69.9%), and anticoagulation monitoring ($n=64$, 68.8%). A significant proportion highlighted the necessity of comprehending the variations in care for cardiopulmonary resuscitation between venovenous and venoarterial ECMO ($n=63$, 67.7%), monitoring of ECMO machine performance and troubleshooting of oxygenator-related issues ($n=57$, 61.3%), ECMO physiology ($n=54$, 58.1%), patient transport logistics ($n=53$, 57.0%), blood transfusion requirements ($n=52$, 55.9%), and ECMO indications and contraindications ($n=51$, 54.8%). Forty-one (44.1%) participants determined the subject of cannulation techniques in ECMO (Fig. 4).

Participants were asked to identify the essential competencies required for proficient nursing care in ECMO facilities. The most frequently recommended skills were the evaluation of ECMO equipment for circuit integrity, clot detection, air accumulation, and patient placement ($n=88$, 94.6%), as well as physical assessment to identify symptoms of hypoperfusion ($n=84$, 90.3%). Other extensively referenced competencies included monitoring blood volume, electrolytes, and coagulation parameters ($n=83$, 89.2%), assessing infection risk ($n=83$, 89.2%), and evaluating intravenous catheters, infusion systems, and ventilator apparatus ($n=83$, 89.2%). Furthermore, critical competencies encompassed support with ECMO-related catheter insertion or oxygenator modifications ($n=81$, 87.1%), monitoring of limb circulation ($n=81$, 87.1%), neurological status evaluation ($n=79$, 84.9%), respiratory assessment

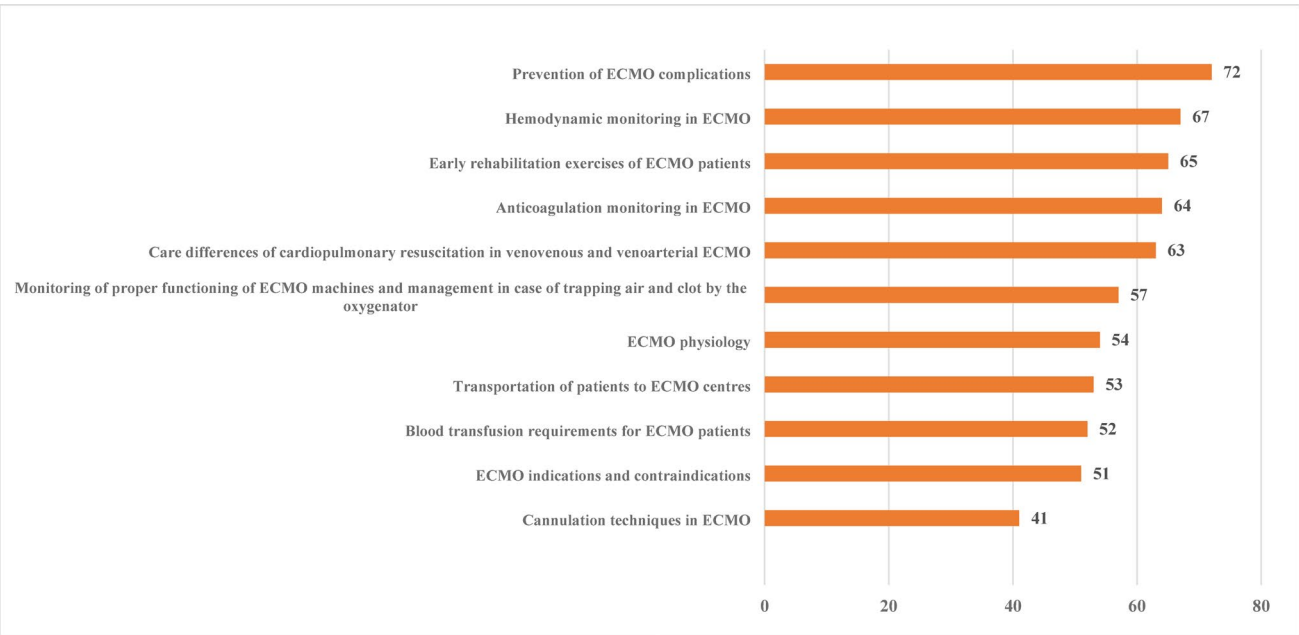

Fig. 4 Essential topics for ECMO nurses training. More than one option is possible

($n=79$, 84.9%), kidney function evaluation ($n=78$, 83.9%), and assistance with intubation procedures ($n=71$, 76.3%).

Participants were requested to pinpoint pharmacological themes that are critical for ECMO nurse education. The predominant theme chosen was anticoagulation management in ECMO ($n=76$, 81.7%). Subsequently, antimicrobial drug therapies ($n=65$, 69.9%) were chosen, followed by sedative and analgesic therapies ($n=63$, 67.7%), and diuretic therapies ($n=56$, 60.2%).

Participants were asked whether ECMO nurses should modify drug dosages under physician oversight. Fifteen (16.1%) participants strongly agreed, 28 (30.1%) agreed, 15 (16.1%) remained neutral, 30 (32.3%) disagreed, and 5 (5.4%) strongly disagreed.

Participants were also asked about their involvement in ECMO-related scientific endeavors, including participation in clinical trials, reporting to registries, or contributing to systematic or narrative reviews. Sixteen (17.2%) respondents acknowledged past engagement in academic or research endeavors, whereas 77 (82.8%) participants indicated lack of experience in these domains.

Perspectives on the significance of educational features in ECMO training

Participants' perspectives on key components of ECMO nurse education were evaluated by multiple opinions assessed on a 5-point Likert scale, with 1 indicating 'Not important' and 5 indicating 'Extremely important.' Response frequencies were examined to emphasize the perceived importance of each instructional component.

Thirty-nine (41.9%) individuals deemed the participation of certified ECMO physicians in training courses as extremely important, whereas 2 (2.2%) participants considered it not important at all.

The participation of certified ECMO nurses in training courses is crucial, with 66 (71%) participants deeming it extremely important, while 2 (2.2%) considered it not important.

Regarding participation in ECMO-related societies, such as ELSO, 29 (31.2%) participants deemed it extremely important. In the context of participation in nursing societies such as AACN, only 21 (22.6%) participants deemed it extremely important. In assessing the importance of research in the ECMO domain, 33 (35.5%) respondents deemed it extremely important.

Assessment of information source for ECMO nurse self-education

Participants were asked to evaluate various information sources for self-education in ECMO nursing. A 5-point Likert scale was utilized, with 1 denoting "not valuable at all" and 5 signifying "extremely valuable." Leading academic journals in the field, including those indexed in Scopus, Web of Science, Medline, and the Directory of Open Access Journals (DOAJ), were considered the most important source of information. A total of 37 (39.8%) participants assessed these sources as "extremely valuable".

The perspectives on international nursing journals indexed in global databases were as follows: 19 (20.4%) respondents assessed them as "extremely valuable," while 35 (37.6%) indicated that they were "not valuable at all." Seventeen (18.3%) participants deemed local nursing journals as "extremely valuable," whereas 32 (34.4%) participants assessed them as "not valuable at all."

Perspectives on social media platforms, including YouTube, that offer ECMO-related content: 33 (35.5%) respondents classified them as "extremely valuable," while 7 (7.5%) assessed them as "not valuable at all."

The ELSO ECMO guidelines include instructional materials. Thirty-three (35.5%) participants considered them as "extremely valuable," whereas 23 (24.7%) classified them as "not valuable at all."

Identified barriers to efficient nursing practice and factors contributing to burnout in ECMO facilities

Participants identified barriers that impede effective ECMO nursing practices by selecting all relevant items. The limited availability of courses to enhance the competence of ECMO nurses was the most frequently identified issue, reported by 42 (45.2%) responders. Additional barriers included a shortage of ECMO specialist nurses ($n=40$, 43%) and excessive workload faced by ECMO nurses, especially instances where one nurse managed multiple ECMO patients during a shift ($n=40$, 43%). Equally, 40 (43%) respondents recognized the lack of appreciation for the job of ECMO nurses. Lastly, 30 (32.3%) participants identified problems related to collaboration and insufficient oversight by ECMO physicians (Fig. 5).

Participants highlighted multiple challenges that substantially elevate workload and risk of burnout among ECMO nurses. The predominant issue reported was the need for continuous monitoring of patients' conditions 24 h a day, as indicated by 47 (50.5%) participants. Forty-five (48.4%) respondents reported the prolonged hospitalization of ECMO patients. 41 (44.1%) participants reported the occurrence of adverse events during ECMO procedures, and acute care issues in ECMO patients present significant complexity, as noted by 38 (40.9%) respondents. Nineteen (20.4%) participants acknowledged the necessity for continuous monitoring of ECMO device functionality (Fig. 6).

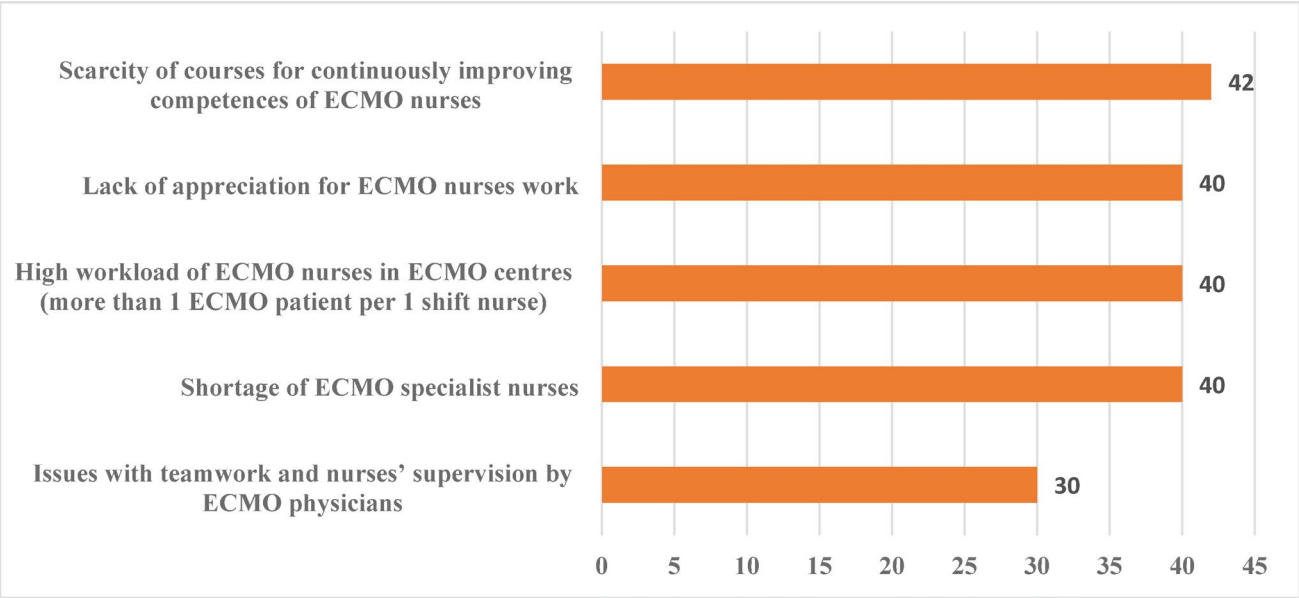

Fig. 5 Perceived barriers to effective nurse practice in ECMO centres. More than one option is possible

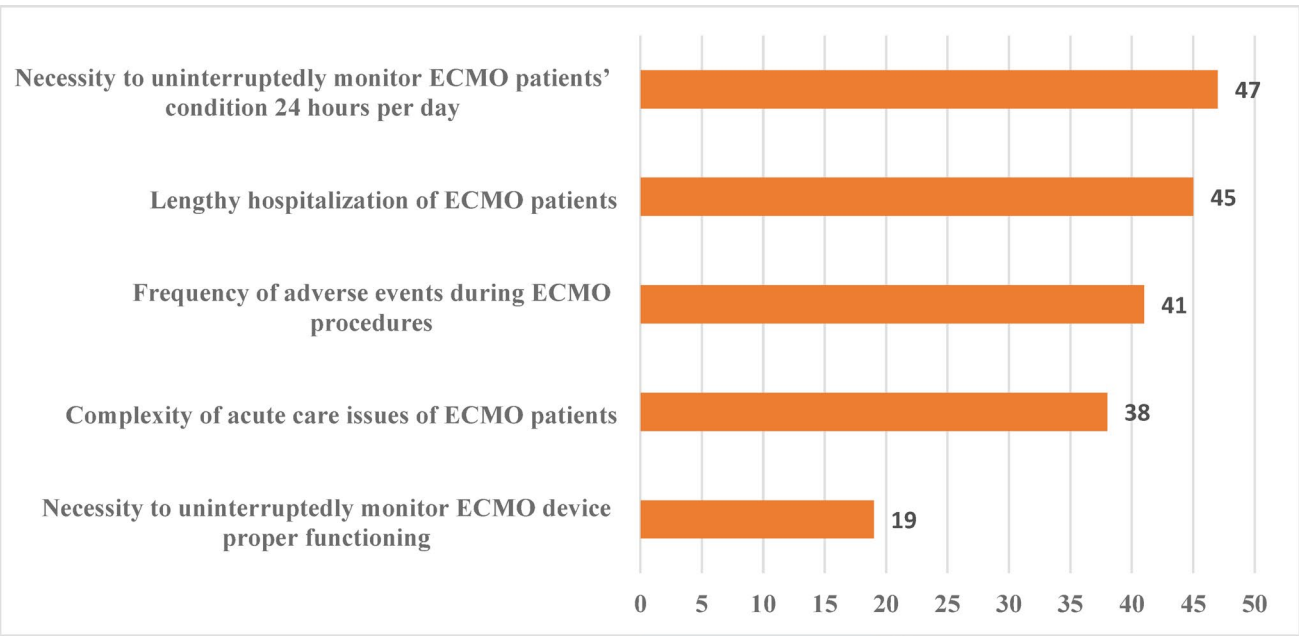

Fig. 6 Main difficulties that increase ECMO nurses' workload and leading to burnout/exhaustion. More than one option is possible

Strategies for enhancing ECMO nurse engagement: perspectives from open-ended question

In response to the open-ended inquiry concerning the enhancement of ECMO nurse participation in ECMO centers, the qualitative comments were classified into principal thematic categories.

The predominant issue identified for enhancement related to education was underscored by 70 (75.3%) participants, who emphasized the necessity for improved access to organized educational programs.

A group of 7 (7.5%) participants emphasized the need to decrease workload. Furthermore, 7 (7.5%) participants discussed the matter of salary and financial incentives.

Discussion

Participant characteristics

Health professionals participating in this survey came from different countries and disciplines. The majority of respondents were from Kazakhstan (66.7%) and the United States (12%). This distribution provides a unique insight into the perception of ECMO practices in health systems with varying levels of development [17].

In terms of professionals, nurses (38%) were the majority, followed by ECMO nurse (23%), anesthesiologist (10%), and perfusionist (9%). This variability reinforces the multidisciplinary aspect of ECMO care [18, 19]. The fact that diverse professions responded to the questionnaire allowed a multi-perspective appraisal of nurses' roles.

Perceptions of ECMO nursing roles and standards of practice

The findings indicated that the majority of health professionals were familiar with the core definition of ECMO by MeSH. This suggests that the overarching conceptual framework of ECMO is broadly recognized throughout the professional community. However, only 45.2% of the participants reported familiarity with the ELSO guidelines, an essential reference for ECMO practice [20, 21]. This indicates that a primary obstacle to uniformity in ECMO clinical practice is the limited accessibility of guidelines. A robust integration of educational content with global sources is essential to enhance understanding and maintain uniformity of practice.

Almost three-quarters of participants agreed with the statement, "ECMO nurses play a central role in the management of ECMO-supported patients". ECMO nurses are viewed as critical figures of ECMO procedures [22]. Nurses' roles in ECMO extend beyond the practitioner level. They play an active part in patient management, a role generally acknowledged by the survey responders.

The majority of the participants stated that the optimal ECMO nurse-patient ratio should be 1:1 for effective nursing care. This finding indicates a strong professional consensus that ECMO patients have high intensive care needs and that one-to-one nurse follow-up is crucial for patient safety [23].

ECMO nurse training

The results indicate that the institutional educational framework for ECMO nurses is predominantly insufficient; 63.4% of participants stated that such training is not provided in their respective healthcare institutions. The most preferred educational format was face-to-face courses (59%), suggesting that participants prioritize education models that offer theoretical knowledge and one-on-one practice opportunities. It can be asserted that hands-on training is a critical requirement for high-risk clinical applications, including ECMO, and advanced technology [24].

The participants' statements regarding the training content indicate that ECMO nurses require a wide range of knowledge and skills to provide adequate care. Specifically, 77.4% of participants identified ECMO complication prevention as essential, 72% identified hemodynamic monitoring as essential, and 70% identified early mobility as essential. Moreover, anticoagulation management, the differentiation of resuscitation techniques based on ECMO types, and the consistent emphasis on technical information regarding device operation demonstrate that nurses actively participate not only in clinical care but also in equipment management and advanced interventions [25].

Among the participants, 95% identified the evaluation of ECMO equipment integrity as the most critical nursing competency, followed by the physical assessment of hypoperfusion signs (90%), monitoring of blood volume, electrolyte, and coagulation parameters (89%), and management of intravenous catheters, infusions, and ventilation systems (89%). These high rates indicate that ECMO nursing is a multifaceted profession that necessitates the integration of technical, clinical, and monitoring competencies.

Only 17% of participants reported active involvement in scientific studies related to ECMO, including participation in clinical research, contributing data to registry systems, or preparing systematic reviews. Arguably, ECMO nursing practices are primarily field-based, with limited contributions to research and evidence growth. It also highlights the need to bridge the gap between clinical knowledge and research output.

Barriers to nursing practice in ECMO units

The survey results indicate that the primary barriers in ECMO nursing practice are insufficient educational opportunities (45%), shortage of expert nurses (43%), and excessive workload (43%). The data point to complex issues necessitating strategic approaches at both institutional and infrastructural levels. The shortage of nurses and their high workload increase the risk of physical and mental burnout, while the absence of educational opportunities restricts their professional development [26].

The necessity for 24-hour, uninterrupted patient monitoring was identified as a major risk factor for burnout among ECMO nurses (50%). This is followed by patients' long-term hospitalization (48.4%) and the frequency of adverse events observed during the procedure (44%). These findings

underscore the importance of organizational support mechanisms in mitigating physical and mental burdens.

Increasing ECMO nurse involvement

The analysis of the open-ended question revealed that a substantial proportion of participants (75%) identified professional development opportunities as the most important factor in increasing the efficiency of ECMO nurses. Improving the efficiency of ECMO nurses could be achieved through comprehensive and robust training programs [27]. Optimizing working conditions and factors that increase professional motivation are also critical [28].

Rheumatological perspective

RDs comprise a notable subset necessitating ECMO due to multiorgan involvement, systemic inflammation, and autoimmunity. The intricate characteristics of RDs demand that ECMO nursing include sophisticated evaluation, immunological comprehension, and multidisciplinary collaboration for this patient group [29, 30]. Nurses play a critical role in rheumatology care by routinely monitoring disease activity, detecting early signs of systemic deterioration, and guiding patients through complex treatment pathways. In rheumatology, these skills are particularly valuable when acute organ failure occurs, and advanced supportive modalities such as ECMO are required [31].

The patients may develop emergencies that may rapidly progress to severe respiratory or cardiac failure. In these life-threatening conditions, ECMO can serve as a bridge to maintain oxygenation or circulation while immunosuppressive or disease-specific therapies are administered [30]. The immune dysregulation observed in RDs may interact with immunological reactions produced by the ECMO circuit, such as complement activation, cytokine release, thromboinflammatory response, and hemolysis, making patients' clinical outcomes more unpredictable [32]. This combination can lead to hazards such as relapses and increased treatment-related adverse effects. As a result, ECMO nurses should comprehend pathophysiology of RDs, signs of autoimmune flares, and possible interactions between immunosuppressive drugs and the ECMO circuit.

Future directions: rheumatological aspect

The complex immune-mediated pathophysiology of RDs, their multifaceted involvement, and their severe clinical manifestations requiring intensive care generate a substantial clinical and scientific deficit in ECMO nursing. Although the need for ECMO care in this patient group is progressively acknowledged, specialized ECMO nursing procedures, monitoring instruments, and educational frameworks for RDs remain unstandardized. Subsequent research should investigate the impact of ECMO circuit-induced immunological responses on different RDs, the risk of autoimmune exacerbations, and the interplay between immunosuppressive treatment regimens and ECMO. Therefore, establishing multidisciplinary education programs and collaborative care models integrating rheumatology, intensive care, and immunology is a priority. Enhancing data-collection systems, consistently reporting ECMO results in RDs to global registries, and including nursing outcome metrics in these registries would facilitate the formulation of more precise clinical recommendations in the future.

Limitations

This study, while offering valuable information on ECMO nursing, had some limitations. The relatively small number of participants may restrict the generalizability of the findings. The disproportionate geographical representation of responders is another limitation, limiting the generalizability. Administering the questionnaire in English may limit participation among healthcare professionals with limited English proficiency. Given that nursing education trajectories, degree structures, and job definitions vary considerably across countries, cross-country heterogeneity may have affected participants' interpretations of nursing skills and responsibilities.

Conclusion

The findings of this survey suggest that nurses are essential in caring for patients undergoing ECMO, requiring advanced clinical knowledge, technological proficiency, and ongoing monitoring capabilities.

A considerable proportion of participants indicated the absence of ECMO-specific nursing education within their institutions. Nevertheless, a significant desire remained for organized, face-to-face educational frameworks. Participants specifically highlighted prevention of complications, hemodynamic monitoring, and anticoagulant treatment as key areas for education.

To enhance the efficacy of ECMO nursing, it is essential to invest in educational infrastructure, develop standardized competence frameworks, and restructure work settings in a supportive manner. These steps are essential for enhancing nursing practices and ensuring the sustainability of ECMO programs.

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Data avaialbility Raw data can be provided by the corresponding author upon reasonable request.

Declarations

Conflict of interest The authors declare no conflicts of interest.

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Evaluating the Quality and Reliability of YouTube as a Source of Information on Extracorporeal Membrane Oxygenation: A Call to Publish More Quality Videos by Professionals

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ABSTRACT

Background: Extracorporeal membrane oxygenation (ECMO) is a medical intervention employed to provide life-sustaining support for patients. YouTube is a dynamic and widely utilized platform for distributing health-related information. The aim of this study was to evaluate ECMO-related videos on YouTube and assess the frequency of misleading information in the accumulation of ECMO videos.
Methods: On September 17, 2024, an in-depth examination on YouTube was conducted using search phrases "Extracorporeal Membrane Oxygenation" and "ECMO treatment." The study included 55 selected videos. Video parameters and sources were analyzed. Content assessments were conducted utilizing the Global Quality Scale (GQS), the modified DISCERN instrument, the *Journal of the American Medical Association* (JAMA) Benchmark Criteria, and the Patient Education Materials Assessment Tool for Audio/Visual Materials (PEMAT-A/V). The authors conducted comparisons among quality groups.
Results: Among the 55 videos analyzed, 30.9% (n = 17) were categorized as low quality, 21.8% (n = 12) as intermediate quality, and 47.3% (n = 26) as high quality. Physicians (75%) provided the most high-quality videos. News outlets (83.3%) provided the most low-quality videos. No statistically significant difference was observed between quality groups in daily views, likes, and comments ($P > 0.05$). Significant correlations were identified between video duration and GQS ($r = 0.585$), modified DISCERN questionnaire ($r = 0.557$), JAMA Benchmark Criteria ($r = 0.511$), PEMAT-A/V Understandability ($r = 0.530$), and PEMAT-A/V Actionability scores ($r = 0.433$) ($P < 0.001$ for all correlation analyses).

Data Sharing Statement
Raw data can be provided to readers on reasonable requests.

Author Contributions
Conceptualization: Permenov BA, Zimba O, Yessirkepov M, Qumar AB, Suigenbayev D, Kocyigit BF. Data curation: Permenov BA, Zimba O, Suigenbayev D. Formal analysis: Kocyigit BF. Investigation: Permenov BA, Zimba O, Yessirkepov M, Qumar AB, Suigenbayev D, Kocyigit BF. Methodology: Permenov BA, Zimba O, Yessirkepov M, Qumar AB, Suigenbayev D, Kocyigit BF. Software: Kocyigit BF. Visualization: Kocyigit BF. Writing - original draft: Permenov BA, Zimba O, Yessirkepov M, Qumar AB, Suigenbayev D, Kocyigit BF. Writing - review & editing: Permenov BA, Zimba O, Yessirkepov M, Qumar AB, Suigenbayev D, Kocyigit BF.

Conclusion: There is a wide variety in the quality of YouTube ECMO videos. Although YouTube content created by physicians is more likely to provide accurate and beneficial information, substandard videos present a significant public health threat by disseminating misinformation. The critical role of quality control methods on social media platforms in ensuring the accurate and high-quality transmission of health-related information is readily evident.

Keywords: Extracorporeal Membrane Oxygenation; ECMO Treatment; Social Media; Internet; Information Science

INTRODUCTION

Extracorporeal membrane oxygenation (ECMO) is a temporary medical approach to sustain life-saving assistance for individuals suffering from cardiovascular diseases, lung disorders, and respiratory distress. This assistance is provided until the patient's organ systems begin to recover or other treatment strategies are attempted.[1,2] ECMO redirects blood through an extracorporeal system, facilitating oxygenation and carbon dioxide elimination from the individual's tissues before reintegration into circulation. This technology is an instrument for enabling recuperation, donating or transplanting an organ, or determining terminal medical needs.[3] The number of healthcare institutions providing ECMO support has risen over the past years, and the use of ECMO for organ failure has expanded.[4]

Veno-venous ECMO is a viable alternative for primary respiratory failure that is unresponsive to conventional medical treatment and where mechanical ventilation fails to facilitate sufficient recovery.[5] Veno-arterial ECMO supplies carbon dioxide-oxygen and electromechanical circulatory assistance, particularly helpful in isolated cardiac dysfunction or concurrent cardiac-pulmonary failure.[6]

The coronavirus disease 2019 (COVID-19) pandemic has raised global awareness of ECMO, making it a key option for patients with severe respiratory failure who are unresponsive to traditional approaches.[7] With an emergence of COVID-19-related conditions resulting in acute respiratory distress syndrome (ARDS), ECMO has been increasingly utilized to offer life-saving assistance.[8] The increased use of ECMO during the pandemic has raised concerns regarding its potential benefits and challenges and a growing interest in understanding its indications.

In recent years, the Internet has emerged as the primary source for health-related information, with the public actively searching for medical advice, treatment alternatives, and insights into intricate medical technologies online.[9] Platforms like YouTube have become essential tools for patients and healthcare professionals. YouTube is now an indispensable platform for analyzung health professionals' online activities and interactions with the society.[10] YouTube's free accessibility and global use make it critically important for disseminating health information, particularly treatment approaches.[11] Nonetheless, the videos' quality, accuracy, and reliability vary widely, raising concerns about misleading information or poor educational content.[12] As an increasing number of healthcare providers and patients utilize YouTube to elucidate treatment strategies, evaluating the reliability and usefulness of these materials is essential.

This study aimed to assess the quality of YouTube videos regarding ECMO therapy. It seeks to examine the characteristics of the videos and discover the sources that deliver high-quality

content. The study examines the link between video presentation techniques and their quality. The results provide insights into the use of YouTube videos on ECMO and perspectives of publishing quality materials by skilled professionals with interest in ECMO therapy.

METHODS

Screening of YouTube videos was conducted on September 17, 2024, utilizing the search phrases "Extracorporeal Membrane Oxygenation" and "ECMO treatment." Search phrases were selected from MeSH terms. All cookies and browsing history were deleted since YouTube prioritizes personalized results. This aimed to mitigate the influence of previous internet usage. The Google Chrome web browser was configured to incognito mode to guarantee anonymity before the search procedure. Results were presented via "relevance-based sorting" as the standard option, emulating the conventional habits of an average customer seeking on the page.[13,14] Based on the findings of studies revealing that most individuals tend to restrict their exploration of internet search outcomes to the first few pages, the primary focus of our investigation was to examine the 50 videos for each search phrase.[15] The criteria for exclusion were established as follows: 1) videos in languages besides English, 2) recurred videos, 3) unrelated videos, 4) videos shorter than 1 minute and longer than 60 minutes, and 5) videos with audio or visual issues. Videos shorter than 1 minute were omitted due to insufficient depth and comprehensiveness for delivering beneficial educational content, particularly regarding the intricate medical procedure of ECMO. These brief videos may emphasize rapid summaries, promotional content, or partial explanations that fail to fulfill the objective of comprehensive information distribution. Conversely, videos beyond 60 minutes were omitted to preserve the emphasis on content corresponding to standard user engagement patterns on YouTube.

The video examination procedure involved two researchers making independent assessments of the videos. The independent judgments were juxtaposed at the conclusion of the procedure, and inconsistencies were observed. A third researcher made the final decision on these videos. Cohen's kappa coefficient was utilized to evaluate the concordance in their ratings.[16]

Video parameters

The metrics for each video's views, likes, and comments were obtained from YouTube. The length of the video was tracked and documented in seconds. The duration from the first upload date of the video to the search procedure was calculated and recorded. Using this data, the daily numbers for views, likes, and comments were calculated. The objective was to minimize the influence of the video upload date on video parameters by computing daily values.

Videos were categorized into four categories based on the presentation technique: 1) videos using only narrators, 2) videos emphasizing patient experiences, 3) videos incorporating animations, and 4) videos using slide presentations. The image quality of the videos was recorded as a low definition (≤ 360p), standard definition (480p), or high definition (≥ 720p).

Video sources

We focused on video sources on YouTube and recorded whichever of the following categories they fit: 1) university-hospital, 2) government organization, 3) physician, 4) non-profit organization and association, 5) health-related website, 6) academic, 7) internet user, 8) patient, 9) non-physician health worker, and 10) news outlets.

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Assessment of video content

The quality was examined using the Global Quality Scale (GQS), a well-recognized tool for assessing internet-based materials' instructional worth and practicality. There are five parts to the GQS. Scores range from 1 (the lowest possible) to 5 (the highest possible). If the score is 1, it shows no consistency and significant gaps in the presented data. Alternatively, a score of 5 shows considerable consistency, which is very helpful. Videos are ranked as high quality if they have a total score of 4 or 5 and intermediate quality if they receive a score of 3. The low-quality category is reserved for videos with a score of 1 or 2.[17,18]

The reliability evaluation was conducted with the modified DISCERN instrument. This tool evaluates many dimensions, including clarity, intelligibility, bias, objectiveness, and the incorporation of references and supplementary materials. The approach employs dichotomous queries, assigning a value of one for favorable responses and zero for unsuccessful responses. The maximum score attainable with this method is 5.[19]

The *Journal of the American Medical Association* (JAMA) Benchmark Criteria are guidance to assess the trustworthiness and quality of online health information. These criteria evaluate essential components that guarantee the reliability of online materials, encompassing authorship, attribution (accurate referencing of sources and data), disclosure, and currency (indicating the publication date and ensuring information is up-to-date).[20]

The Patient Education Materials Assessment Tool for Audio/Visual Materials (PEMAT-A/V) is a systematic tool intended to assess the understandability and actionability of visual and auditory health information materials. Understandability assesses the ease with which patients may grasp information, emphasizing clarity, organization, vocabulary, and visual aids. Actionability evaluates whether the materials explicitly delineate steps that patients may take to manage their condition. PEMAT-A/V is frequently employed to evaluate the quality of online medical materials to ensure their accessibility and usefulness for patients. Scores are expressed as a percentage.[15,21]

Statistical analysis

The authors employed Statistical Package for Social Sciences version 29.0 software (IBM Corp., Armonk, NY, USA) for statistical analyses. Before executing any analysis, adherence to normal distribution was assessed using the Shapiro-Wilk test. Data were provided as median (minimum-maximum) and number with percentage. Three distinct quality groups were established, and intergroup comparisons were conducted utilizing the Kruskal-Wallis test. The Spearman rho test was utilized for correlation analyses. The Kappa coefficient was computed to evaluate consistency. Interpretations of statistical significance of *P* values are based on a threshold of 0.05.

RESULTS

The top 50 videos for each search term were listed to highlight the most relevant and fitting videos. A total of 100 videos were evaluated; 45 were excluded based on the criteria, resulting in 55 videos being included in the analysis. **Fig. 1** illustrates further details regarding the sampling method. The median duration of the videos was 219 (71–2,797) seconds. The median number of views, likes, and dislikes were 4,615 (208–1,547,318), 34 (0–20,000), and 1 (0–896), respectively. Of all videos, 38.2% (n = 21) were presented with narrators only, 21.8%

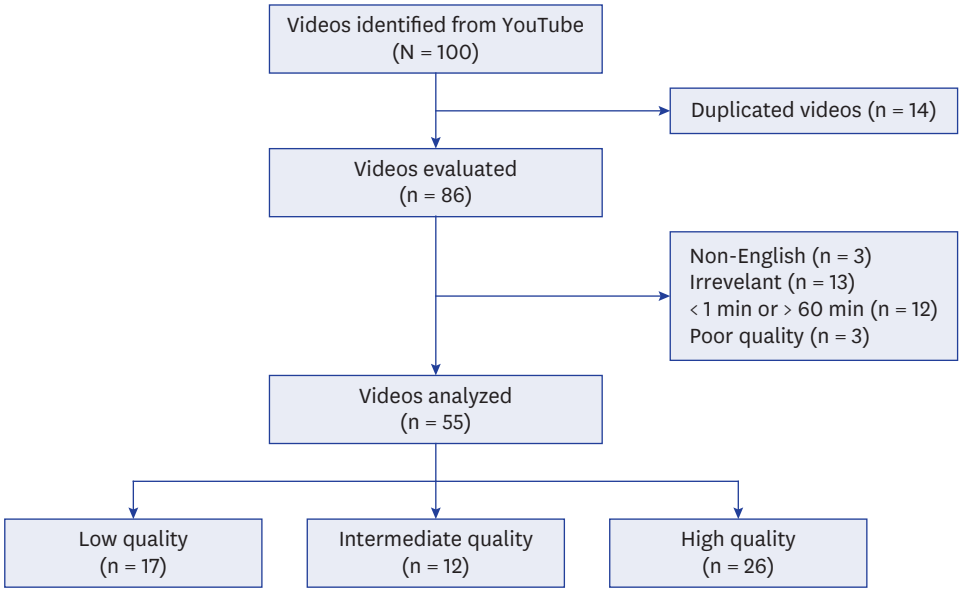

Fig. 1. The flowchart delineates the procedure for selecting YouTube videos.

Table 1. General features of the videos

Variables	Values
Video features	
Duration, sec	219 (71–2,797)
Number of views	4,615 (208–1,547,318)
Number of likes	34 (0–20,000)
Number of comments	1 (0–896)
Days since upload	1,443 (463–4,498)
Views per day	4,615 (208–1,547,318)
Likes per day	0.03 (0–13.17)
Comments per day	0 (0–0.58)
Presentation method	
Video containing only narrator(s)	21 (38.2)
Video containing patient experiences	12 (21.8)
Animation	8 (14.5)
Narrating with a slide presentation	14 (25.5)
Image quality	
Low definition (≤ 360p)	42 (76.4)
Standard definition (480p)	13 (23.6)
High definition (≥ 720p)	0 (0.0)

Data are expressed as median (minimum–maximum) or numbers (percentage).

(n = 12) with patient experiences, 14.5% (n = 8) with animations and 25.5% (n = 14) with slide presentations. The main characteristics of the videos are summarized in **Table 1**.

The videos were divided into three groups: low, intermediate, and high quality, according to GQS scores, and 30.9% (n = 17) of the videos were in the low, 21.8% (n = 12) in the intermediate, and 47.3% (n = 26) in the high-quality group. Video sources were analyzed according to quality groups. The source provides high-quality videos, with the highest percentage being physicians (75%). On the other hand, the source providing low-quality videos with the highest percentage was news outlets (83.3%) (**Table 2**, **Fig. 2**).

No statistically significant difference was detected when quality groups were compared based on views, likes, and comments per day (**Table 3**).

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Table 2. Categorization of the videos according to sources

Source	Low quality	Intermediate quality	High quality	Total
University-Hospital	7 (25.0)	7 (25.0)	14 (50.0)	28 (100.0)
Physician	0 (0.0)	1 (25.0)	3 (75.0)	4 (100.0)
Non-profit organization	1 (12.5)	3 (37.5)	4 (50.0)	8 (100.0)
Health-related website	4 (44.4)	1 (11.2)	4 (44.4)	9 (100.0)
News outlets	5 (83.3)	0 (0.0)	1 (16.7)	6 (100.0)

Data are expressed as numbers (percentage).

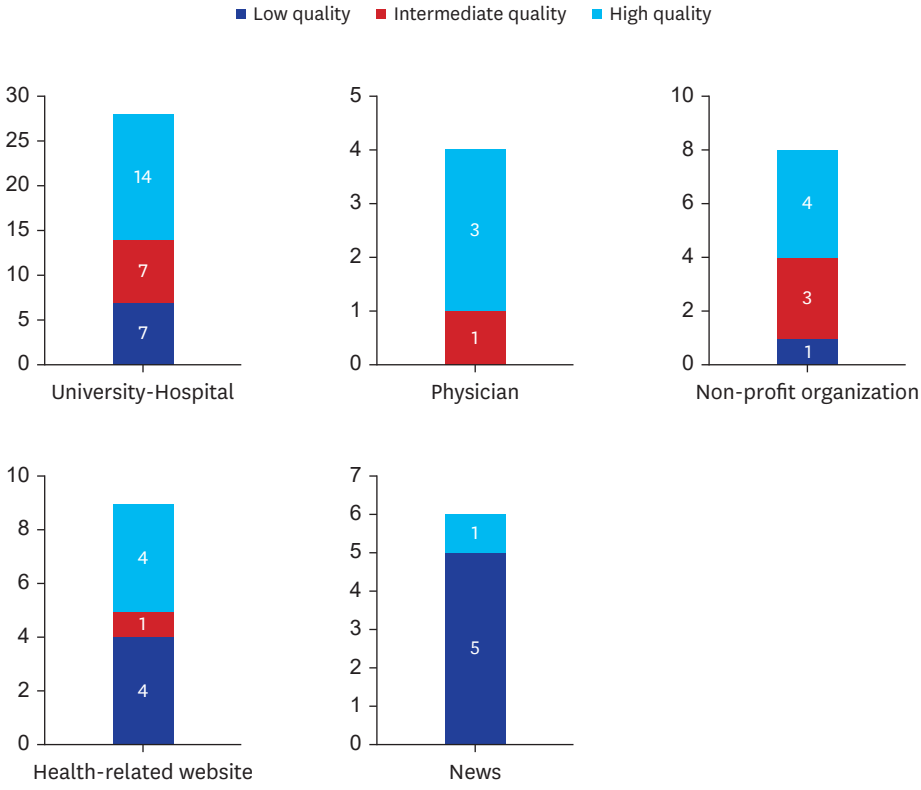

Fig. 2. Low, intermediate, and high-quality video distributions according to video sources.

Table 3. Comparison of the video parameters between the low-quality, intermediate, and high-quality groups

Parameters	Low quality	Intermediate quality	High quality	*P* value
Views per day	3.45 (0.25–118.13)	1.66 (0.17–26.16)	9.63 (0.22–587.46)	0.216
Likes per day	0.03 (0–0.68)	0.01 (0–0.22)	0.05 (0–13.17)	0.234
Comments per day	0 (0–0.16)	0 (0–0.01)	0.01 (0–0.58)	0.075

Data are expressed as median (minimum–maximum).

Analyses demonstrated that the scores of the video assessment instruments were significantly and positively correlated with each other ($P < 0.001$; **Fig. 3**). Furthermore, correlation analyses were conducted between the video assessment instrument scores and video parameters. Significant and positive correlations were identified between video duration and GQS, modified DISCERN questionnaire, JAMA Benchmark Criteria, PEMAT-A/V Understandability, and PEMAT-A/V Actionability scores ($P < 0.001$). A significant and positive correlation existed between the days since upload and JAMA Benchmark Criteria scores ($P < 0.05$). In addition, daily comments possessed a significant positive correlation with modified DISCERN questionnaire scores ($P < 0.05$; **Table 4**).

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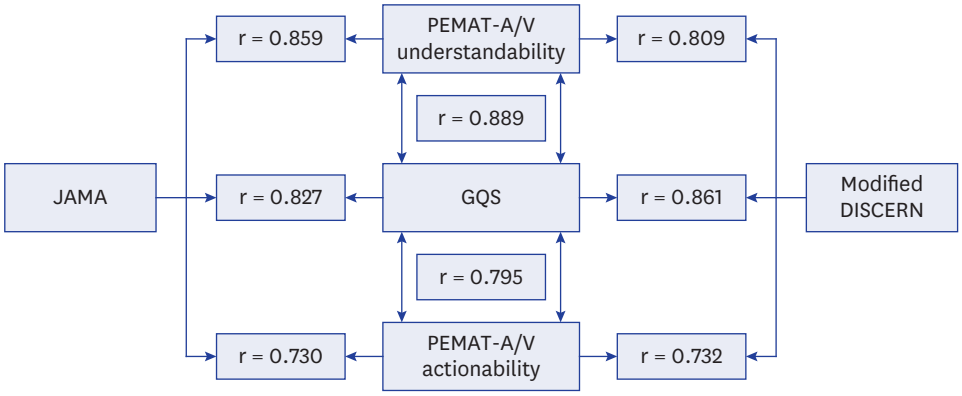

Fig. 3. Correlation analyses between video content assessment instruments.
The rho value between JAMA Benchmark Criteria and modified DISCERN questionnaire is 0.900.
$P < 0.001$ in all correlation analyses.
JAMA = *Journal of the American Medical Association*, GQS = Global Quality Scale, PEMAT-A/V = Patient Education Materials Assessment Tool for Audio/Visual Materials.

Table 4. Correlation analysis between content scores and video parameters

Parameters	GQS	Modified DISCERN questionnaire	JAMA Benchmark Criteria	PEMAT-A/V Understandability	PEMAT-A/V Actionability
Video duration	0.585**	0.557**	0.511**	0.530**	0.433**
Days since upload	0.063	0.246	0.269*	0.089	0.158
Views per day	0.186	0.185	0.182	0.143	0.154
Likes per day	0.139	0.135	0.120	0.094	0.147
Comments per day	0.230	0.268*	0.234	0.183	0.266

GQS = Global Quality Scale, JAMA = *Journal of the American Medical Association*, PEMAT-A/V = Patient Education Materials Assessment Tool for Audio/Visual Materials.
*$P < 0.05$, **$P < 0.01$.

Table 5. Comparison of the presentation methods in terms of video quality

Video quality	Video containing only narrator(s)	Video containing patient experiences	Animation	Narrating with a slide presentation	*P* value
Low-quality	4 (19.0)	9 (75.0)	3 (37.5)	1 (7.1)	0.009**
Intermediate-quality	5 (23.8)	2 (16.7)	1 (12.5)	4 (28.6)	
High-quality	12 (57.1)	1 (8.3)	4 (50.0)	9 (64.3)	
Total	21 (100.0)	12 (100.0)	8 (100.0)	14 (100.0)	

Data are expressed as numbers (percentage).
**$P < 0.01$.

Video presentation methods were compared in terms of quality groups. The presentation that provided the highest percentage of high-quality video was 'narrating with a slide presentation' (64.3%). On the other hand, the presentation that provided the highest percentage of low-quality video was 'video containing patient experiences' (75%) ($P = 0.009$; **Table 5**).

A Kappa coefficient of 0.84 was determined.

DISCUSSION

The current study examined YouTube videos as an important tool for spreading information regarding ECMO. In the current landscape, where the Internet is a pervasive source of information, it is essential to assess the reliability and quality of materials distributed on online platforms, including YouTube.[22] The key points of this study are as follows:

- Less than half of the ECMO videos are classified as high quality, while nearly one-third are deemed low quality.

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- Physicians are the leading providers of high-quality videos, while news outlets are the source of low-quality videos.
- The quality groups do not differ in the daily values of the video parameters.
- The scores of the video assessment instruments exhibit significant positive correlations with each other.

Despite the favorable outcomes of nearly 50% of videos being deemed as high quality and a relatively limited proportion of low-quality videos, it is critical to consider the issue. Low-quality videos are associated with dissemination of erroneous, insufficient, and biased information.[23] The presence of low-quality videos poses a threat to public health. Misinformation about critical medical procedures such as ECMO may seriously impact patient decisions and healthcare provider opinions. For patients and caregivers seeking life-saving medical information, such as ECMO therapy, erroneous or negatively presented content may lead to misconceptions regarding the treatment's hazards, advantages, or appropriate use. The emergence of these issues motivate professional associations, particularly Extracorporeal Life Support Organization (ELSO; https://www.elso.org), to document and disseminate credible videos regarding ECMO mechanisms, indications, advantages, and efficacy. ECMO videos should be understandable for non-expert audiences, especially relatives of patients who may benefit from ECMO. The variation in ECMO use and availability across countries necessitates the creation of multi-language videos or English videos supplemented with subtitles in multiple languages. Focusing on topics of the personnel involved in ECMO administration, timelines for efficiency assurance, and awareness campaigns would be helpful.

One of the main outcomes of the current study is that physicians generated the highest percentage of high-quality videos, implying that healthcare professionals provide accurate and relevant information regarding ECMO. In contrast, news outlets yielded the highest percentage of low-quality videos, raising concerns regarding the credibility of news outlets-related information for healthcare. This result is consistent with prior research that identified healthcare professionals as the most reliable source of online medical information.[24,25] Given the significance of ECMO as a sophisticated and critical intervention, consumers who obtain information via online platforms must acknowledge content from verified sources such as physicians or institutions.

No statistically significant differences were found when comparing the quality categories' daily views, likes, and comments. This result suggests that engagement measures like views, likes, and comments may not always be an adequate means to gauge the quality of health-related videos.[26,27] Instead, video reliability and quality were more closely correlated with duration, with longer videos scoring better on all assessment instruments, including GQS, modified DISCERN questionnaire, JAMA Benchmark Criteria, and PEMAT-A/V. This might imply that longer videos present more extensive explanations and are more appropriate for instructional purposes.[28,29]

The analysis of video presentation methodologies indicated that the most efficacious approach for conveying high-quality content was the integration of narration with slide presentations. This research indicates that organized presentations, including clear graphics and narratives, deliver comprehensive, high-quality content more effectively.[30] On the other hand, videos showcasing patients' experiences had a higher percentage of low-quality content, showing that, while personal narratives can be appealing, they may lack the educational rigor necessary

to transmit correct health-related information. This result emphasizes the need to balance engaging storytelling with reliable, high-quality YouTube content.

The instruments used to evaluate video reliability and quality (GQS, modified DISCERN questionnaire, JAMA Benchmark Criteria, and PEMAT-A/V) are compatible with each other and work well together, as shown by the significant correlations identified among them. This result proves that these tools are reliable for evaluating the quality of health-related videos on YouTube.

This research has several limitations. The omission of non-English videos may restrict the generalizability of the findings to non-English-speaking audiences. The study was planned as cross-sectional due to the dynamic nature of YouTube content, rendering longitudinal research impractical. The video screening was performed anonymously to prevent consumer biases. Therefore, anyone looking for the phrases "Extracorporeal Membrane Oxygenation" and "ECMO treatment" may come across videos that differ from the ones used in the current study, thereby affecting the generalisability of these results. The quality and reliability of videos were examined at a particular time point. It is essential to acknowledge that search results may fluctuate over time. We limited the number of videos examined for each search phrase. A greater number of video assessments would have yielded more complete results.

In conclusion, this study emphasizes that while YouTube can be a powerful tool to disseminate information regarding ECMO treatment, considerable variability exists in the content's quality. Videos created by physicians and healthcare organizations were often of high quality, but those from news outlets or showcasing patient experiences generally had lower quality. Efficient presentation techniques, such as narrating with slide presentations, are crucial for delivering reliable instructional content. The critical function of quality control methods on social media platforms in guaranteeing an accurate and high-quality dissemination of health-related information becomes evident. Internet users must take caution, emphasizing proper citation and thoroughly scrutinizing content for any advertising, misleading, or substandard information on YouTube within the evolving digital landscape.

Involving specialist editors in editing, publishing, and aggregating ECMO would be an effective strategy.[31] Endorsing quality videos by ELSO and other associations with interest in ECMO and then pooling these videos on respective resource platforms may improve professional understanding of numerous aspects of ECMO.

Healthcare professionals may face various challenges that affect the quality of ECMO-related educational videos. Balancing the complexity of ECMO with the necessity of making the information accessible to a broad audience presents a considerable challenge. ECMO is a specialized and complex procedure, necessitating precise communication of its technical aspects to patients, carers, and non-medical audiences while maintaining accuracy. Healthcare professionals must ensure their explanations are scientifically accurate while avoiding jargon that may confuse the public. Healthcare professionals should develop innovative methods to convey information engagingly, utilizing animations, visuals, and patient narratives while maintaining the educational integrity of the content. Addressing these challenges necessitates that healthcare professionals function as educators, proficient communicators, and content creators.

Further initiatives are required to enhance awareness regarding health-detrimental videos on YouTube that advocate ECMO technology by commercial entities while obscuring their intrinsic limitations and to evaluate YouTube's strengths and weaknesses.[32]

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Healthcare professionals' views on training, standards, and resources for extracorporeal membrane oxygenation: a cross-sectional survey

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Aim To assess health care professionals' knowledge and opinions regarding extracorporeal membrane oxygenation (ECMO) use, training, standards, and resource availability.

Methods This cross-sectional study employed an online self-administered survey to evaluate health care professionals' knowledge and opinions concerning ECMO procedures. The survey consisted of multiple-choice and open-ended questions inquiring about demographics, ECMO practices, training and certification experiences, ECMO use during the COVID-19 pandemic, and obstacles to ECMO implementation.

Results The study enrolled 89 health care professionals from 12 countries. The respondents were most frequently from Kazakhstan (67.4%), Turkey (5.6%), Croatia (5.6%), and Ukraine (5.6%). Notably, 61.8% of respondents supported ECMO procedures performed by certified specialists. The respondents believed that the main ECMO indications were respiratory failure (83.1%), cardiopulmonary failure (69.6%), heart and lung transplantation (64.1%), and cardiogenic shock (58.4%). Major obstacles to ECMO implementation were reported to be high costs (53.9%), inadequately qualified staff (52.8% for physicians, 41.6% for nurses), and restricted availability of ECMO devices (42.7%).

Conclusion The findings emphasize the need for standardized training, wider availability of ECMO standards, and efforts to address resource-related barriers to ECMO access. Our results primarily reflect practices in Kazakhstan and should be interpreted in light of the study's restricted geographical coverage.

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Extracorporeal membrane oxygenation (ECMO) is a complex life-sustaining procedure intended for individuals with refractory cardiac or respiratory failure unresponsive to conventional procedures (1). ECMO enhances gas exchange and hemodynamic stability by channeling the patient's blood through an external oxygenator, functioning as an artificial lung, and can either assist or completely substitute cardiac function (2). This advanced technology has been widely utilized in critical care, particularly for acute respiratory distress syndrome (ARDS), cardiac shock, and perioperative assistance during transplantation (3-5). In the COVID-19 pandemic, ECMO had been prioritized as a crucial therapeutic alternative for patients experiencing severe acute respiratory failure non-responsive to mechanical ventilation, functioning as a life-saving measure in severe viral pneumonia and respiratory failure (6,7).

The increasing use of ECMO has generated considerable interest in its clinical effectiveness and safety. Survey-based research is essential since it provides real-world data on practice trends, clinical experiences, and health care professionals' views on ECMO procedures (8-10). Such studies are used to identify knowledge gaps, practice disparities, and obstacles to the broad adoption of ECMO, particularly in resource-limited health care systems. Furthermore, survey approaches enable evaluation of ECMO training programs, underscoring their efficacy in skill development and the essential contribution of multidisciplinary teams to improved patient survival and procedural outcomes (11,12).

Despite the growing body of clinical data supporting ECMO use, there is limited information on how health care professionals perceive ECMO training, certification standards, and institutional readiness, particularly in resource-limited and transitional health care settings. Rather than broadly assessing all aspects of ECMO practice, the current study focuses on health care professionals' perspectives on ECMO training, certification standards, and resource-related barriers, which are the most critical determinants of safe and sustainable ECMO implementation.

The aim of the survey was to explore the health care professionals' views on ECMO availability, prominent indications, the perceived efficacy and safety of the intervention, and obstacles to ECMO implementation. These domains reflect the essential structural, clinical, and organizational aspects that directly impact decision-making, patient selection, and the practicality of ECMO use in routine clinical settings. Assessing availability and indications helps identify disparities in access and clinical prioritization, whereas evaluating perceived efficacy, safety, and implementation barriers sheds light on professional confidence, institutional readiness, and system-level constraints affecting ECMO delivery.

RESPONDENTS AND METHODS

This cross-sectional study used an online self-administered survey to assess health care professionals' knowledge, perceptions, and practices concerning ECMO procedures. The target population comprised health care professionals engaged in the care of critically ill patients, including physicians, nurses, and allied health care professionals from diverse specialties. The survey employed the SurveyMonkey.com platform.

Survey design

The questionnaire items were formulated based on an extensive review of relevant and evidence-based literature. The questionnaire primarily adhered to the guidelines of the Extracorporeal Life Support Organisation (ELSO) (https://www.elso.org/ecmo-resources/elso-ecmo-guidelines.aspx).

The questionnaire addressed ECMO definitions, indications, functions, components of the ECMO team, types of ECMO, and complications. It encompassed aspects of ECMO use during crises such as the COVID-19 pandemic. It also addressed the qualifications of ECMO team members and the obstacles they faced. Furthermore, it inquired about ECMO-related training protocols.

Five experts reviewed the survey content to improve its clarity and ensure consistency and validity. Two stages of revisions were conducted. In the pretest stage, ten health care professionals from various disciplines were contacted to complete the survey on the SurveyMonkey.com platform. The findings were evaluated, and the questionnaire was modified according to the received feedback.

The final version of the questionnaire (Supplemental Material 1) is divided into four sections: ECMO-related definitions, knowledge, and experiences; ECMO-related training; barriers to ECMO use and ECMO in the pandemic period; and sociodemographic information. The questionnaire consists of 37 questions: 22 multiple-choice, 7 Likert-type (on a 1-5 scale, with 1 – not important and 5 – extremely important), and 1 open-ended question. The completion time was approximately 10 minutes.

Respondents were permitted to modify their responses before concluding the survey but not afterwards. To guarantee that incomplete responses were promptly eliminated, all inquiries were designated as mandatory on the SurveyMonkey platform.

Sampling

Between July 23, 2024 and September 26, 2024, the questionnaire link was disseminated on X (Twitter), Facebook, and WhatsApp. The study investigators distributed the survey link throughout the study period to engage a convenience sample of health care professionals. No specific sampling approach was employed; participation was voluntary and self-selected.

The study was approved by the Ethics Committee of the South Kazakhstan Medical Academy. Before completing the survey, respondents were informed that their answers would only be used for research purposes, and their informed consent was obtained.

Confidentiality, integrity, and availability

The research employed internet protocol (IP) identifiers and respondent emails as the sole identifying indicators of the respondents. The moderator ensured data confidentiality by securing IP addresses and emails. The synthesized data were subsequently accessible in anonymized databases. This report adheres to the principles of designing and reporting survey studies (13).

Statistical analysis

Descriptive data are presented as numbers and percentages. The differences between the groups were evaluated with the χ^2 test. The level of statistical significance was set at $P < 0.05$. The statistical analysis was conducted with SPSS, version 25.0 (IBM Corp., Armonk, NY, USA).

RESULTS

Respondents' characteristics

The survey was completed by 89 individuals, with a median age of 40 (range 24-84) years. Most of the respondents were anesthesiologists (n = 43, 48.3%) and intensivists (42 or 47.2%) (Figure 1). Respondents worked in public hospitals (n = 64, 71.9%), university-affiliated hospitals (n = 14, 15.7%), private hospitals (n = 9, 10.1%), and other institutions (n = 2, 2.3%). Thirty (33.7%) participants indicated that their health care facilities possessed a specialized department or unit

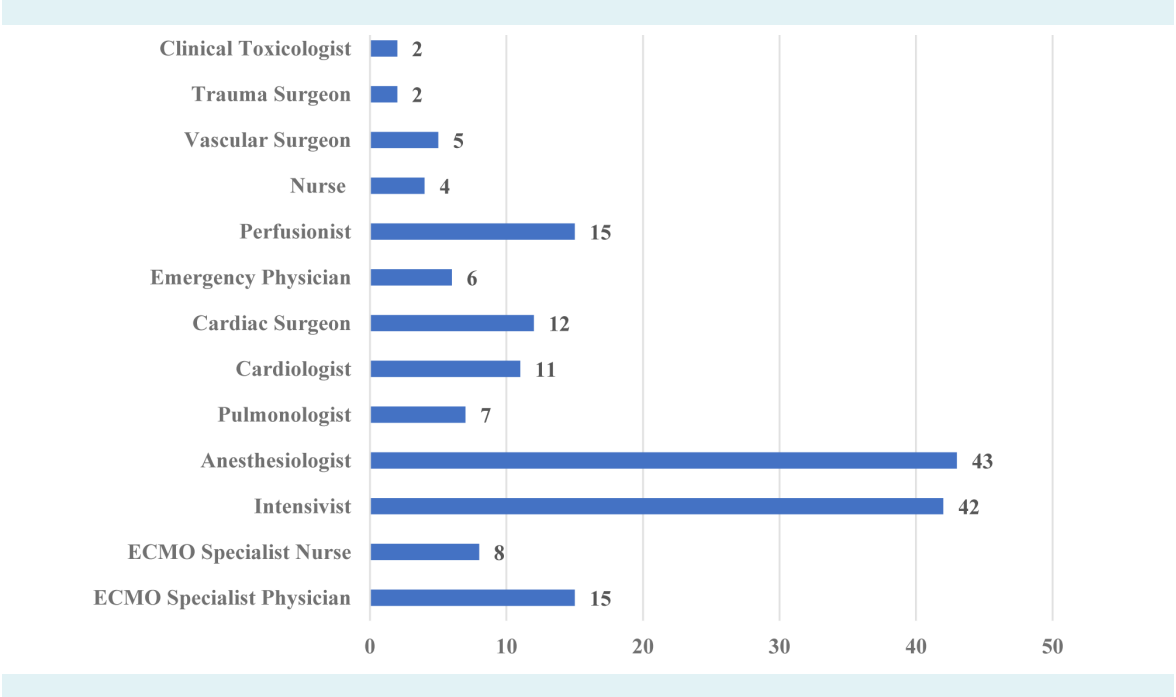

FIGURE 1. Respondents' specialties. ECMO – extracorporeal membrane oxygenation.

for ECMO. Eighty-three (93.3%) worked in urban health care settings, whereas 6 (6.7%) worked in rural areas.

Among the participants, 11 (12.4%) had been practicing as health professionals for less than 1 year, 21 (23.6%) for 1 to 5 years, and 57 (64%) for more than 5 years. The participants' experience in emergency medicine was as follows: 10 (11.2%) participants had less than 1 year of experience, 21 (23.6%) had 1 to 5 years of experience, and 58 (65.2%) had more than 5 years of experience.

The respondents originated from 12 countries, mostly Kazakhstan (n = 60, 67.4%), Turkey (n = 5, 5.6%), Croatia (n = 5, 5.6%), and Ukraine (n = 5, 5.6%) (Figure 2). In statistical analysis, countries were categorized into Kazakhstan and others. The two groups did not significantly differ in ECMO availability ($P = 0.711$, χ^2 test), health care professional experience ($P = 0.524$), or the duration of time the participants engaged in emergency medicine ($P = 0.199$).

Definitions, knowledge, and experiences

A total of 73 (82%) participants were familiar with the ECMO definition, and 55 (61.8%) were familiar with the Extracorporeal Life Support Organization (ELSO) guidelines. Most participants agreed that ECMO was effective and safe for critically ill patients (60.7%), while 27.0% were neutral and 12.4% disagreed or strongly disagreed.

Respondents believed that health care professionals who should be involved in ECMO procedures were primarily certified ECMO specialists (75.3%), intensivists (60.7%), cardiothoracic surgeons (57.3%), perfusionists (56.2%), and ECMO nurses (55.1%) (Figure 3). Most respondents agreed that ECMO should be administered only by certified specialists (61.8%), while 12.4% were neutral and 25.8% disagreed or strongly disagreed. Respondents most frequently reported respiratory failure (n = 74, 83.1%), cardiopulmonary failure (n = 62, 69.6%), and heart and lung transplantation (n = 57, 64.1%) as indications for ECMO (Figure 4). The factors most commonly considered when initiating or discontinuing ECMO included overall clinical benefit (n = 56, 62.9%), survival chances (n = 50, 56.2%), comorbidities (n = 49, 55.1%), and predicted post-ECMO quality of life (n = 45, 50.6%) (Figure 5).

Overall, 48 participants (53.9%) reported that their medical centers offered ECMO support. Regarding annual ECMO case volume, 34 respondents (38.2%) reported no procedures, while 37 (41.6%) reported fewer than 30 procedures per year. Concerning institutional experience, 31 participants (34.9%) reported providing ECMO for 5 years or less, 14 (15.7%) for more than 10 years, and 34 (38.2%) were not sure. The most commonly reported ECMO modes were venoarterial (n = 42, 47.2%) and venovenous (n = 36, 40.4%) (Figure 6). Anticoagulant preferences during ECMO were as follows: heparin (n = 75, 84.3%), unfractionated

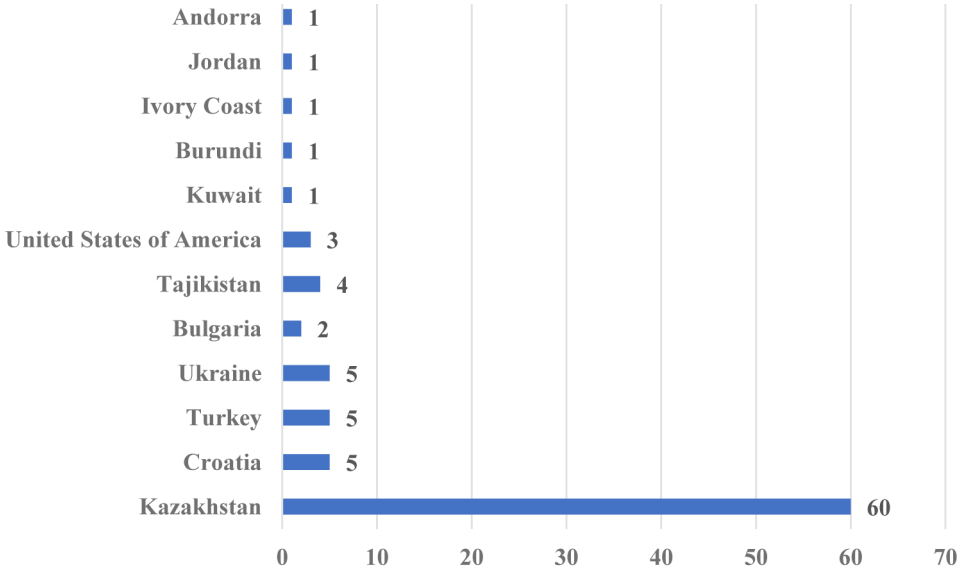

FIGURE 2. Respondents' countries of origin.

heparin (n = 16, 18%), argatroban (n = 5, 5.6%), bivalirudin (n = 4, 4.5%), warfarin (n = 2, 2.2%), and rivaroxaban (n = 1, 1.1%). The primary antimicrobial therapeutic strategies were based on antimicrobial characteristics (n = 59, 66.3%) and did not differ from those used in therapies for critically ill patients (n = 25, 28.1%).

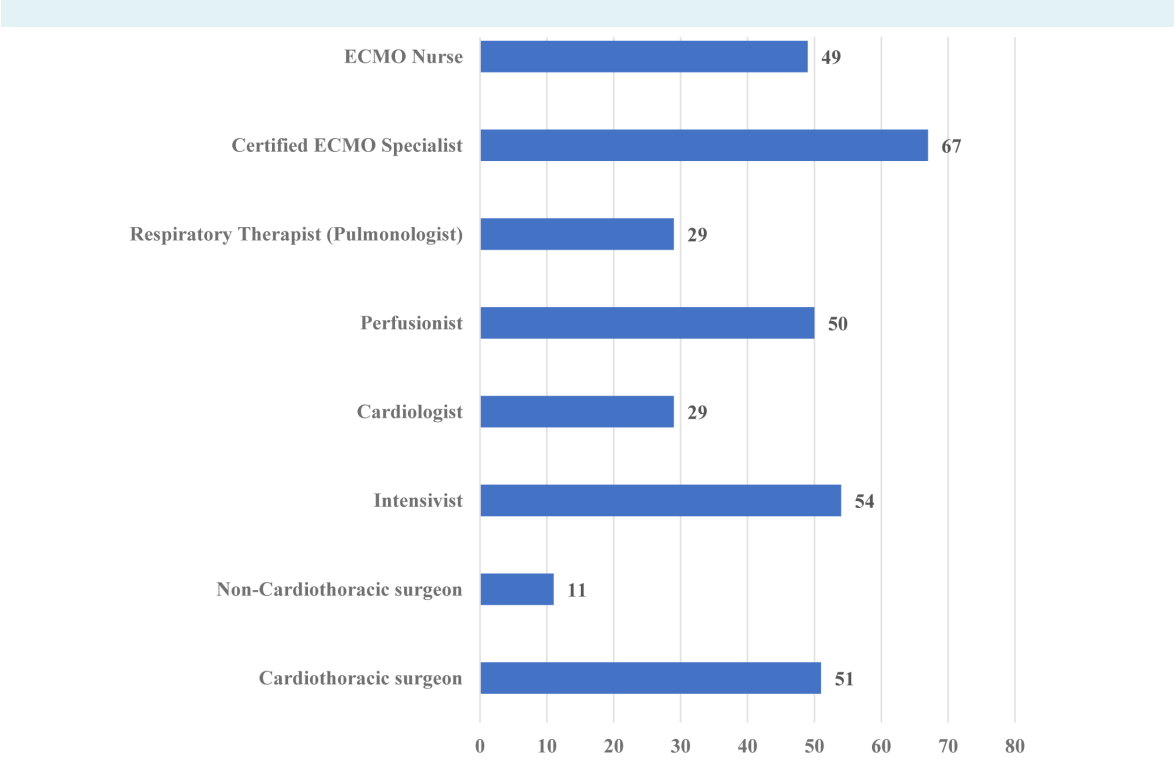

FIGURE 3. Respondents' choice of health care professionals who should be involved in extracorporeal membrane oxygenation (ECMO) procedure to reduce risks and improve patient survival.

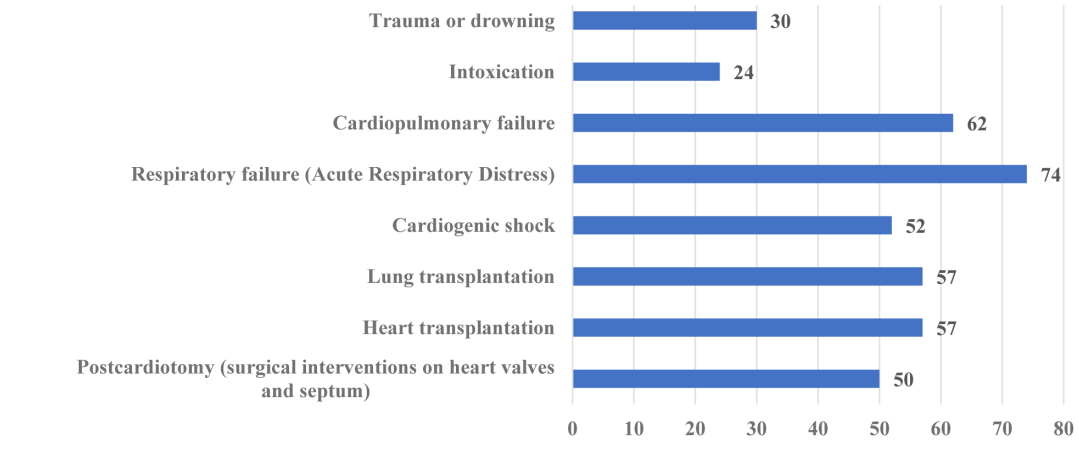

FIGURE 4. Extracorporeal membrane oxygenation (ECMO) indications as reported by the respondents.

ECMO training

Thirty-one participants (34.8%) reported that ECMO training was available at their medical centers. The most frequently reported training requirements included didactic courses at a specialist center with lectures, seminars, and handouts (n = 54, 60.7%), scenario-based simulation training (n = 53, 59.6%), and residency certification in a relevant specialty (n = 45, 50.6%). Most participants rated didactic teaching by highly skilled ECMO specialists as important or extremely important; 13 respondents (14.6%) rated it as important, and 50 (56.2%) as extremely important.

Simulation-based training was rated as important or extremely important by 64 respondents (71.9%), membership in ECMO-related associations by 54 (60.6%), and research in the field of ECMO by 57 respondents (64.1%). Thirty-six participants (40.4%) reported prior authorship of ECMO-related research.

Barriers to ECMO use and the COVID-19 period

The most frequently reported barriers to ECMO use were high procedural costs (n = 48, 53.9%) and a limited number of ECMO-trained physicians (n = 47, 52.8%) (Figure 7).

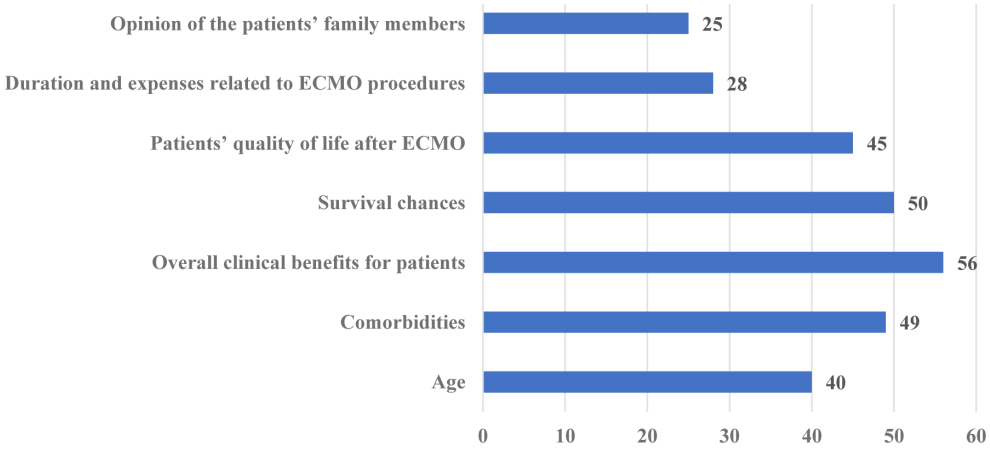

FIGURE 5. Factors considered when deciding to initiate or discontinue extracorporeal membrane oxygenation (ECMO) as reported by the respondents.

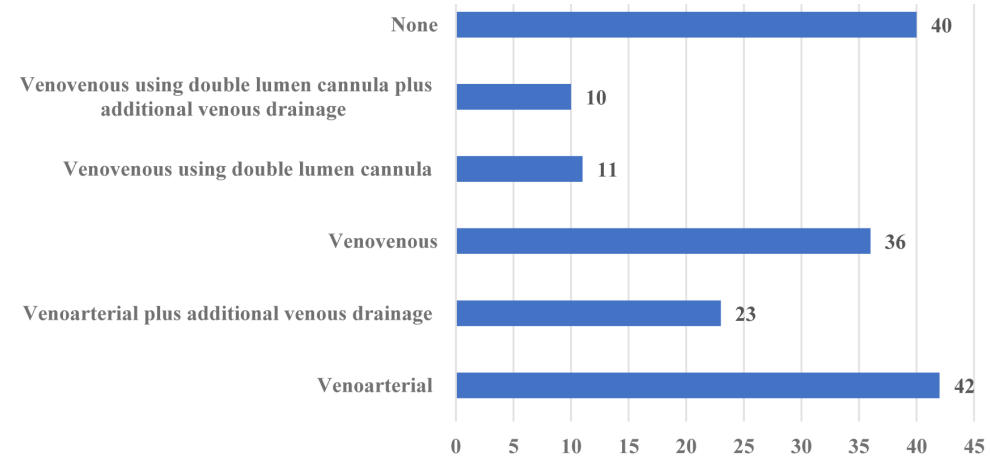

FIGURE 6. The extracorporeal membrane oxygenation (ECMO) modes offered in medical centers as reported by the respondents.

Sixty (67.4%) participants managed critically ill COVID-19 patients referred to ECMO. Thirty respondents (33.7%) reported that the COVID-19 pandemic did not affect the organization of ECMO procedures in the health care setting at all, 34 (38.2%) reported that the pandemic affected it to some extent, and 25 (28.1%) that it affected it considerably. During the COVID-19 pandemic, 53 (59.6%) responders reported an increase in referrals of COVID-19 patients to ECMO, while 25 (28.1%) noted an increase in referrals of non-COVID-19 patients to ECMO. Regarding ECMO effectiveness, 56.2% of respondents agreed or strongly agreed with its use in critically ill COVID-19 patients, and 55.1% agreed or strongly agreed with its use in critically ill non-COVID-19 patients.

To improve the efficiency of ECMO procedures, 29 responders recommended ECMO training (32.6%), while other recommendations were multidisciplinary training programs, sharing of experiences, online meetings, simulation-based training, and ECMO certification programs.

DISCUSSION

This study suggests that, while the majority of health care professionals recognize the clinical importance of ECMO, significant deficiencies remain in training, certification, and institutional readiness to implement it. These data suggest that deficits in knowledge, workforce capability, and resources are the primary barriers to the safe and sustainable use of ECMO in current practice.

The research involved participants from 12 countries, mostly intensivists, anesthesiologists, perfusionists, and cardiothoracic surgeons. Approximately two-thirds of the responders originated from Kazakhstan. Notwithstanding the variety of participants' specialties, 71.9% worked in public institutions, suggesting that ECMO is primarily incorporated into public health care systems. Importantly, only 33.7% of respondents reported the existence of a specialized ECMO department in their health institution, which underscores the restricted availability of ECMO, particularly in resource-constrained environments (14,15). Conversely, survey-based studies in well-resourced health care systems report higher access to specialized ECMO centers, increased case volumes, and more organized training and certification options for ECMO providers (11,12). These disparities likely reflect discrepancies in health care funding, institutional structure, and the availability of qualified experts. Such variations may partially elucidate the disparities in ECMO availability, education options, and perceived obstacles reported by participants in the current study.

The majority of participants were familiar with the globally acceptable definition of ECMO, and 61.8% were familiar with relevant ELSO guidelines. The obtained results point to good understanding of ECMO among health care pro-

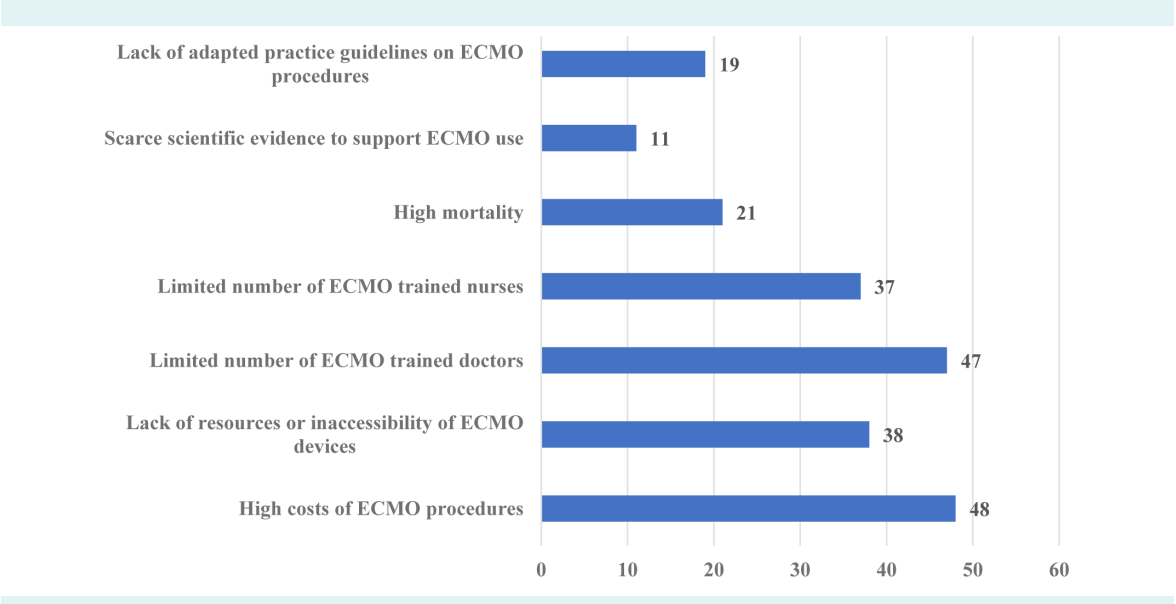

FIGURE 7. Barriers to the widespread use of extracorporeal membrane oxygenation (ECMO) as reported by the respondents.

fessionals, yet a considerable percentage still remain unfamiliar with the guidelines. This underscores the need for enhanced dissemination of ECMO-specific protocols to guarantee uniformity in practice across hospital environments (16,17).

Overall, 60.7% of respondents agreed or strongly agreed that ECMO was efficacious and safe for managing critically ill patients. A substantial proportion of respondents (37.1%) were neutral or disagreed, which might indicate uncertainty or skepticism about ECMO results, especially in high-risk patient scenarios. These findings highlight the continuing discussion on the specific indications and long-term benefits associated with ECMO, particularly in patients with multiple comorbidities or elderly individuals (18,19).

The survey responses underscored the significance of a multidisciplinary approach to ECMO, identifying cardiothoracic surgeons, intensivists, perfusionists, and certified ECMO specialists as crucial team members. Notably, 61.8% of respondents endorsed the necessity for specialists with ECMO certification to perform ECMO procedures, highlighting the importance of standardized training and formal certification. This is essential for minimizing complications and enhancing patient outcomes, especially in high-risk ECMO scenarios (20-22).

Respondents found predominant indications for ECMO to be respiratory failure, cardiopulmonary failure, heart and lung transplantation, and cardiogenic shock. These results correspond with the recognized indications for ECMO use in critically ill patients (23). Notably, trauma and intoxication were cited by 33.7% and 26.9% of respondents, respectively, indicating an increasing acknowledgment of ECMO use in non-cardiopulmonary emergencies. The expansion of ECMO indications aligns with accumulating evidence that supports its use in these situations, especially when standard treatments are ineffective (24,25).

The survey findings on anticoagulant preferences during ECMO point to heparin as a preferred drug. Heparin continues to be the standard anticoagulant in ECMO processes, perhaps owing to its efficacy and availability of related protocols.

Regarding antimicrobial treatment during ECMO, 66.3% of participants formulated their strategy based on the medications' pharmacokinetics, including protein binding qualities, molecular weight, and solubility (hydrophilic/lipophilic features). This demonstrates a focused strategy for antibacterial treatment that considers changed pharmacodynamics during ECMO.

The respondents described the main barriers to ECMO utilization as high costs, restricted availability of ECMO equipment, and a deficiency of ECMO-trained personnel. These results are in line with published reports, emphasizing expensive resource requirements, including equipment and specialized personnel (26). The current survey results highlight the need for advanced training programs to broaden the team of health care professionals qualified to properly deliver ECMO.

During the COVID-19 pandemic, ECMO use was prioritized, with 59.6% of respondents indicating increased referrals of COVID-19 patients to ECMO. This is in line with global trends since ECMO was used as a last-resort treatment for COVID-19 patients with severe ARDS resistant to mechanical ventilation (27). Opinions on the efficacy of ECMO in treating COVID-19 varied, with just 19.2% of respondents expressing significant agreement with its success in such instances. This presumably indicates the difficulties encountered during the pandemic, including patient selection, resource distribution, and elevated mortality rates regardless of ECMO assistance (28).

An important issue in the current study was the need for advanced ECMO training. Only 34.8% of participants stated that their centers offered official ECMO training, with the majority underscoring the value of didactic and simulation-based instructions. This highlights the need for organized ECMO educational programs, including practical training and certification, to provide health professionals with competencies essential for safe and successful ECMO management (29). The respondents suggested extending ECMO training programs through multidisciplinary simulation-based training and ECMO certification. These results are consistent with the survey's overall findings, emphasizing the need for a standardized ECMO education.

A limitation of the current study is a relatively small sample size and convenience sampling, which restrict the generalizability of the findings. Additionally, the respondents were predominantly from Kazakhstan. Consequently, disparities in health care infrastructures, training opportunities, and available resources across countries should be taken into account when interpreting the results.

In conclusion, this cross-sectional survey provides insights into ECMO implementation from the perspective of health

care professionals mostly from resource-constrained and transitional health care environments. The results highlight the necessity for standardized training programs, broader distribution of ECMO standards, and initiatives to overcome resource-related obstacles that restrict ECMO accessibility. As ECMO advances as a life-saving technology, especially following the COVID-19 pandemic, the establishment of comprehensive ECMO education and certification programs is essential for guaranteeing its safe and effective application in various health care environments.

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Ethical approval The study was approved by the Ethics Committee of the South Kazakhstan Medical Academy (protocol N1; May 25, 2024).

Declaration of authorship all authors conceived and designed the study; BAP, OZ acquired the data; all authors analyzed and interpreted the data; BAP, MY, BFK drafted the manuscript; OZ, MY, DS, BFK critically reviewed the manuscript for important intellectual content; all authors gave approval of the version to be submitted; all authors agree to be accountable for all aspects of the work.

Competing interests All authors have completed the Unified Competing Interest form at www.icmje.org/coi_disclosure.pdf (available on request from the corresponding author) and declare: no support from any organization for the submitted work; no financial relationships with any organizations that might have an interest in the submitted work in the previous 3 years; no other relationships or activities that could appear to have influenced the submitted work.

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PUBLIC HEALTH RECOMMENDATIONS

PRACTICAL RECOMMENDATIONS FOR EXTRACORPOREAL MEMBRANE OXYGENATION IMPLEMENTATION IN MULTIDISCIPLINARY HOSPITALS: LESSONS LEARNED FROM FIVE-YEAR EXPERIENCE OF HEART CENTER SHYMKENT

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Abstract

Introduction. Extracorporeal membrane oxygenation (ECMO) has become an essential life-support modality for patients with severe cardiopulmonary failure. However, ECMO programs remain predominantly concentrated in highly specialized centers with cardiothoracic surgery services, limiting access to ECMO in many multidisciplinary hospitals.

Objective. To develop practical recommendations for ECMO implementation in multidisciplinary hospitals without in-house cardiac surgery by integrating international evidence with the five-year institutional experience of the Heart Center Shymkent.

Methods. This study combined a narrative review of international literature on ECMO program development with a retrospective observational analysis of ECMO utilization at the Heart Center Shymkent, between 2019 and 2024. Clinical indications, ECMO configurations, organizational aspects of program development, team structure, and patient outcomes were assessed, with particular attention to staged implementation and integration of ECMO into existing intensive care pathways.

Results. Between January 2019 and December 2024, 91 ECMO procedures were performed in patients with severe cardiopulmonary failure refractory to conventional treatment. The major indications included cardiogenic shock, severe respiratory failure, extracorporeal cardiopulmonary resuscitation, and post-cardiotomy cardiac failure. During the COVID-19 pandemic in 2021, ECMO support was initiated in 12 pregnant and postpartum patients with severe respiratory failure; successful decannulation was achieved in 5 patients (42%). Over the study period, ECMO activity expanded in parallel with the development of multidisciplinary teams, protocol standardization, and structured workforce training.

Conclusion. The experience of the Heart Center Shymkent suggests that a structured ECMO program can serve as a practical, reproducible model for multidisciplinary hospitals without in-house cardiac surgery. A staged implementation strategy based on restricted initial indications, multidisciplinary collaboration, protocolized care, and continuous quality monitoring may support safer and more sustainable expansion of extracorporeal life support in resource-constrained settings.

Keywords: extracorporeal membrane oxygenation, ECMO, implementation, multidisciplinary hospitals, cardiac surgery, critical care, recommendations.

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Introduction

Over the past two decades, advances in extracorporeal circuit technology and critical care management have transformed extracorporeal membrane oxygenation (ECMO) from a rescue intervention into an increasingly standardized component of advanced intensive care practice [1–3]. Global ECMO utilization has steadily increased, reflecting broader clinical experience, improved

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patient selection, and maturation of multidisciplinary care models.

Despite this expansion, access to ECMO remains uneven across healthcare systems. In many countries, ECMO services are concentrated in highly specialized tertiary centers with established cardiothoracic surgery programs. This concentration reflects the technical complexity of extracorporeal support, the need for continuous monitoring of the ECMO circuit, and the requirement for highly trained multidisciplinary teams capable of managing severe respiratory or circulatory failure and ECMO-related complications. At the same time, such centralization may delay access to extracorporeal life support for critically ill patients initially admitted to hospitals without advanced surgical infrastructure [2, 3].

In Kazakhstan, the first ECMO program was introduced in 2011 at the National Scientific Cardiac Surgery Center in Astana, establishing the initial institutional platform for subsequent development of extracorporeal life support in the country. Over time, ECMO practice expanded to regional cardiac centers, including the Heart Center Shymkent. This local experience is important because it reflects the development of an ECMO program outside the national flagship center and provides an opportunity to analyze organizational pathways relevant to broader implementation in the national healthcare system.

The problem is particularly relevant for multidisciplinary hospitals without in-house cardiac surgery. Many patients with refractory cardiogenic shock, severe acute respiratory distress syndrome, or extracorporeal cardiopulmonary resuscitation (ECPR) indications are initially managed in such settings. Although early ECMO initiation may be lifesaving in selected cases, insufficient institutional preparedness, lack of standardized protocols, and limited workforce experience may increase the risks associated with extracorporeal support. Thus, the key question is not only whether ECMO can be performed technically, but under what organizational conditions it can be introduced safely and sustainably [2, 13].

The COVID-19 pandemic further emphasized the need to expand access to ECMO and exposed the limitations of traditional service models. During this period, several healthcare systems strengthened regional ECMO networks based on hub-and-spoke principles, enabling multidisciplinary hospitals to participate in identifying, stabilizing, and referring potential ECMO candidates while maintaining access to specialized expertise [6, 18].

Another critical aspect of ECMO service development concerns workforce capacity and the quality of informational and scientific support. Previous studies have demonstrated substantial heterogeneity in healthcare professionals' views on ECMO training, standards, and resource provision, as well as the central role of nurses in ECMO teams and the need for better structured professional preparation [5, 8, 9]. Together, these findings indicate that sustainable ECMO development depends not only on equipment and case volume, but also on organizational readiness, staff competence, and reliable scientific support.

Therefore, the aim of the present study was to develop practical recommendations for ECMO implementation in multidisciplinary hospitals without in-house cardiac surgery by integrating international evidence with the Heart Center Shymkent's 5-year institutional experience. By combining conceptual analysis with real-world clinical data, this study proposes an organizational framework that may support the safe and sustainable development of ECMO programs in resource-limited healthcare environments.

Materials and Methods

Study Design

This study combined a narrative review of international literature on ECMO program development, workforce organization, and implementation strategies with a retrospective observational analysis of institutional ECMO experience at the Heart Center, Shymkent, between January 2019 and December 2024. The conceptual component of the study identified organizational principles relevant to staged ECMO implementation, while the retrospective component provided real-world data on clinical indications, ECMO utilization, and institutional program development.

Study Setting

The clinical component of the study was conducted at the Heart Center Shymkent, a regional tertiary cardiovascular center in Kazakhstan providing advanced cardiology, cardiac surgery, anesthesiology, intensive care, and related specialized services. Although the present recommendations are intended for multidisciplinary hospitals without in-house cardiac surgery, they were derived from this referral center's experience and interpreted in the context of the published literature on ECMO program development. This approach was chosen because regional ECMO centers may provide transferable organizational experience for hospitals operating in resource-limited or structurally transitional settings.

Institutional ECMO program development

ECMO implementation at the Heart Center Shymkent was carried out in a staged manner. The main stages included:

1. Preparatory phase – institutional readiness assessment, protocol development, staff preparation, and establishment of a multidisciplinary team.

2. Initial implementation phase – ECMO use in selected critically ill patients with gradual development of standardized workflows and decision-making pathways.

3. Program expansion phase – progressive increase in ECMO case volume, broader clinical indications, and deeper integration of extracorporeal support into routine intensive care practice.

The staged organizational framework underlying ECMO program development in the present study is presented in Figure 1.

Patient Population

All adult patients who received ECMO at Heart Center Shymkent between January 2019 and December 2024 were included.

Indications for ECMO therapy included:

All adult patients who underwent ECMO support at the Heart Center, Shymkent, between January 2019 and December 2024 were included in the retrospective analysis. ECMO was used in patients with severe cardiopulmonary failure refractory to conventional treatment. The principal clinical indications included refractory cardiogenic shock, severe acute respiratory distress syndrome, extracorporeal cardiopulmonary resuscitation, post-cardiotomy cardiac failure, and severe COVID-19-associated respiratory failure.

A subgroup analysis was performed for pregnant and postpartum patients who required ECMO support during the COVID-19 pandemic, given the special clinical and organizational complexity of this cohort.

ECMO configuration and cannulation strategy

ECMO configuration was selected according to the dominant pattern of organ failure and the clinical objectives of extracorporeal support. Venovenous ECMO (VV-ECMO) was used in patients with isolated severe respiratory failure, whereas venoarterial ECMO (VA-ECMO) was used in patients with circulatory collapse, cardiogenic shock, extracorporeal cardiopulmonary resuscitation, or combined cardiac and respiratory failure. The cannulation strategy was individualized based on the patient's hemodynamic status, vascular access, urgency of initiating support, and available institutional expertise.

Data collection and outcome measures

Clinical and organizational data were extracted from institutional records and analyzed descriptively. The following variables were assessed: annual ECMO case volume, principal clinical indications, ECMO configuration, successful decannulation, survival to hospital discharge, and major complications. In addition, organizational aspects of ECMO service development were evaluated, including multidisciplinary team formation, protocolization of care, staff training, and integration of ECMO into clinical pathways.

Ethical considerations

The study protocol was evaluated and approved by the Local Bioethics Commission of South Kazakhstan Medical Academy (protocol N8, December 10, 2025). All data were analyzed in accordance with institutional and ethical standards applicable to observational research.

Results

ECMO activity and major indications

Between January 2019 and December 2024, a total of 91 ECMO procedures were performed at the Heart Center Shymkent in patients with severe cardiopulmonary failure refractory to conventional treatment. The principal indications included cardiogenic shock, severe respiratory failure, extracorporeal cardiopulmonary resuscitation, and post-cardiotomy cardiac failure. The main clinical and organizational characteristics of the ECMO program are summarized in Table 1.

Evolution of ECMO practice over time

Over the five-year study period, ECMO practice evolved from a limited rescue intervention into a more structured institutional program integrated into routine intensive care decision-making. This evolution was accompanied by progressive standardization of patient selection, improved multidisciplinary coordination, refinement of cannulation and monitoring practices, and expanded staff training. The annual ECMO case volume over the study period is presented in Figure 2.

Table 1. Annual Distribution of ECMO Indications, Configuration and Outcomes at the Heart Center Shymkent (2019–2024)

Variable	2019 (n=5)	2020 (n=9)	2021 (n=18)	2022 (n=19)	2023 (n=18)	2024 (n=22)	Total n=91 (%)
Severe ARDS	2	9	12	6	6	7	**42 (46.2)**
Post-cardiotomy shock	3	0	5	12	12	15	**47 (51.6)**
ECPR / refractory cardiac arrest	0	0	1	3	5	7	**16 (17.5)**
VV-ECMO	1	5	12	1	2	2	**23 (25.2)**
VA-ECMO	3	4	6	18	16	20	**67 (73.6)**
Successful weaning from ECMO	2	1	6	13	15	16	**53 (58.2)**
Survival	2	0	5	6	6	7	**26 (28.6)**
Complications*	5	12	17	22	21	25	**102 (112.1)**
Pregnant / postpartum patients	0	7	12	0	0	0	**19 (20.8)**
Male patients	3	2	5	13	9	12	**44 (48.3)**
Female patients	2	7	13	6	9	10	**47 (51.6)**

Abbreviations: ARDS, acute respiratory distress syndrome; ECPR, extracorporeal cardiopulmonary resuscitation; VV-ECMO, veno-venous extracorporeal membrane oxygenation; VA-ECMO, veno-arterial extracorporeal membrane oxygenation.
Note: Complications represent the total number of recorded adverse events; more than one complication could occur in a single patient. Indication categories were not mutually exclusive; ECPR was analyzed as a clinical scenario and could overlap with the primary indication for ECMO support.

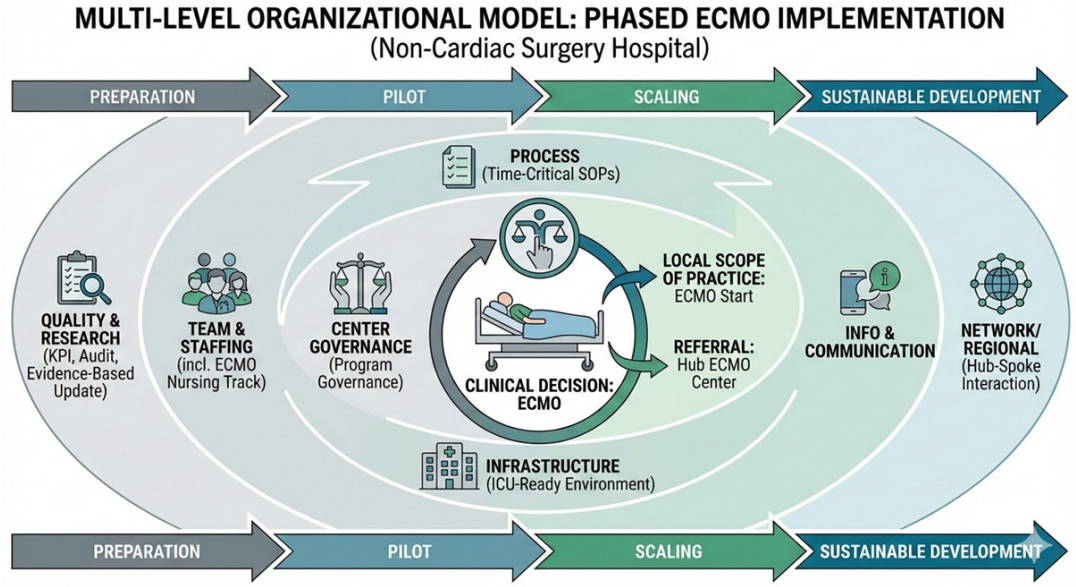
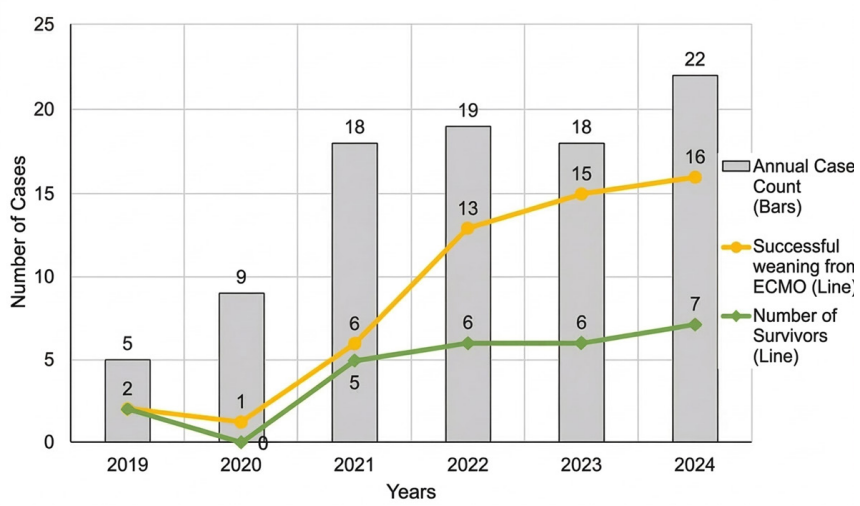


Figure 1. Organizational framework for stepwise ECMO program development in multidisciplinary hospitals without an in-house cardiac surgery service.



Figere 2. Evolution of ECMO utilization and clinical outcomes at the Heart Center Shymkent (2019–2024).

Notes: ECMO — extracorporeal membrane oxygenation.
"Total procedures" refers to the number of ECMO implantations performed annually.
"Successfully weaned" indicates patients in whom extracorporeal support was discontinued following stabilization of hemodynamic and/or respiratory function.
"Discharged" represents patients who survived to hospital discharge.

Obstetric ECMO subgroup during the COVID-19 period

A particularly important phase of ECMO program development occurred during the COVID-19 pandemic in 2021, when the center provided extracorporeal support to 12 pregnant and postpartum women with severe respiratory failure refractory to conventional treatment. This subgroup was among the most clinically and organizationally demanding in the institutional experience. Successful ECMO decannulation was achieved in 5 patients (42%). Figure 3 presents the clinical characteristics and outcomes of this 2021 pregnant/postpartum ECMO cohort only.

Organizational outcomes of program development

The increase in ECMO case volume was accompanied by important organizational changes, including the establishment of a multidisciplinary ECMO team, progressive protocolization of care, structured staff training, and improved integration of extracorporeal support into intensive care pathways. Beyond procedural experience alone, these developments reflected institutional maturation and laid the groundwork for a transferable implementation framework applicable to other multidisciplinary hospitals without in-house cardiac surgery.

Discussion

The present study demonstrates that ECMO implementation in a multidisciplinary hospital without in-house cardiac surgery should be understood not as an isolated technical intervention, but as a staged institutional process requiring organizational readiness, multidisciplinary collaboration, protocolized care, and continued workforce development. The evolution of ECMO activity observed at the Heart Center Shymkent, as shown in Figure 2, supports the concept that safe expansion of extracorporeal life support is closely linked to the maturation of local organizational capacity rather than to procedure availability alone [2,13,18].

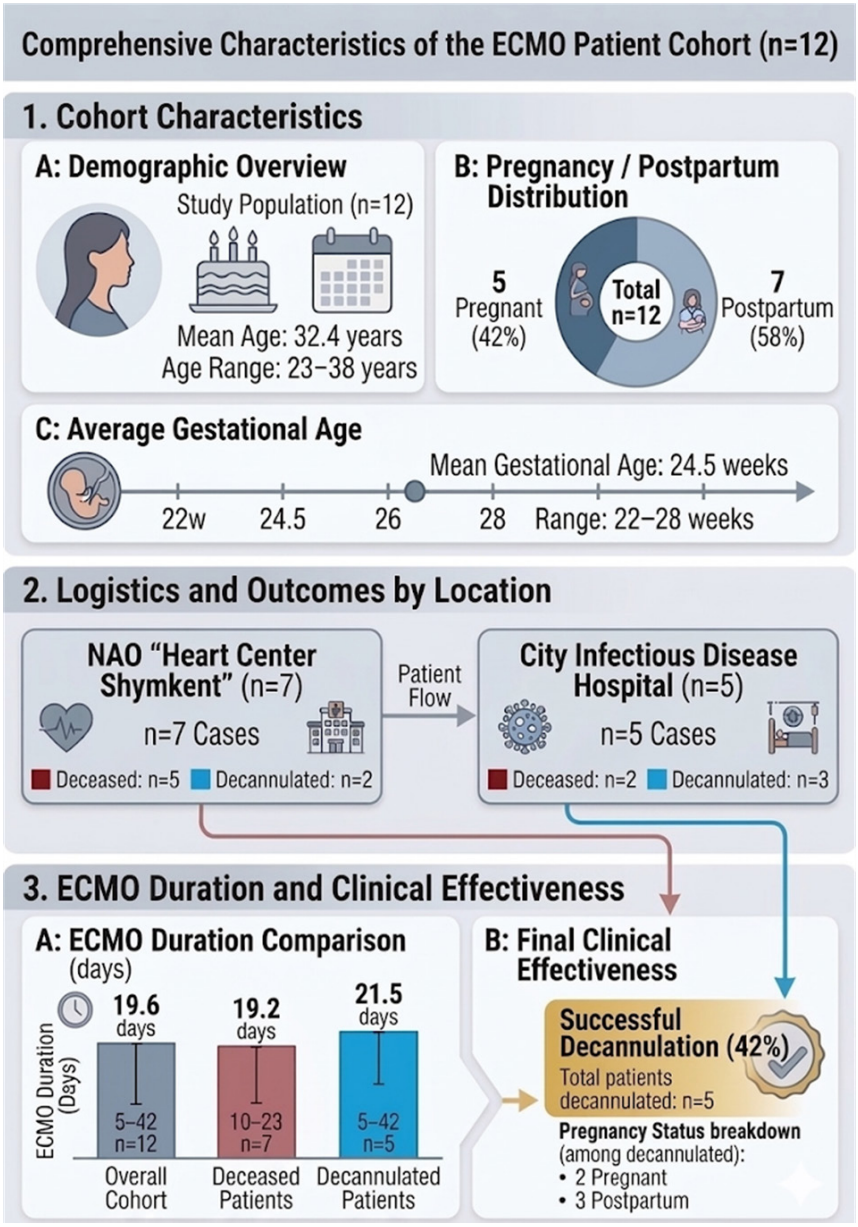
One of the key findings of the study is that institutional preparedness represents a central prerequisite for sustainable ECMO development. Although ECMO has traditionally been concentrated in large cardiothoracic referral centers, increasing clinical demand and the experience of recent public health emergencies have highlighted the need to extend ECMO capabilities beyond national flagship institutions. In this regard, the present study supports the view that multidisciplinary hospitals may participate in ECMO care provided that implementation is based on clearly defined indications, escalation pathways, structured team coordination, and internal quality review. The staged organizational framework summarized in Figure 1 reflects this principle [2,3,13].

The findings also underscore the critical role of the multidisciplinary team. Safe ECMO care depends on close collaboration among intensivists, anesthesiologists, surgeons, perfusionists, nurses, and other specialists involved in the management of severe cardiopulmonary failure. In particular, the nursing component should be regarded as a central operational element of ECMO service delivery because bedside nurses contribute directly to continuous monitoring, early detection of complications, and maintenance of daily circuit safety. Previous survey-based research has shown substantial heterogeneity in ECMO training, staffing models, and role allocation, indicating that workforce development should be considered a core strategic element of ECMO implementation rather than a secondary logistical issue [5,8,9].

The experience gained during the COVID-19 period provides additional insight into the program's organizational resilience. As illustrated in Figure 3, the management of pregnant and postpartum women with severe respiratory failure represented one of the most demanding periods of institutional ECMO practice. This cohort required rapid decision-making, close coordination between intensive care, obstetric, and extracorporeal support teams, and a high degree of organizational flexibility. International experience has similarly shown that ECMO can be feasible in highly complex subgroups when applied within a structured multidisciplinary framework [3,12]. At the same time, these data also support the principle that expansion of ECMO indications should follow, rather than precede, the consolidation of institutional capacity.

From a broader public health perspective, the study suggests that ECMO development in middle-resource settings should rely on staged implementation rather than unrestricted expansion from the outset. The data summarized in Table 1 and the organizational trajectory shown in Figure 2 support a model in which initial focus is placed on institutional readiness, restricted indications, team formation, and internal protocolization, followed by gradual program growth as experience accumulates [2,13,18]. Thus, the value of this work lies not only in reporting local experience but also in proposing a practical, reproducible organizational framework for ECMO implementation in multidisciplinary hospitals without in-house cardiac surgery.

Figere 3. Clinical characteristics and outcomes of pregnant and postpartum patients treated with ECMO (n = 12).



Notes: ECMO — extracorporeal membrane oxygenation.
Decannulation refers to successful discontinuation of ECMO support after stabilization of cardiopulmonary function.
Percentages are calculated relative to the total number of patients in the cohort.

Practical Recommendations for ECMO Implementation in Multidisciplinary Hospitals Without In-House Cardiac Surgery

Based on the integration of international evidence and the institutional experience of the Heart Center Shymkent, summarized in Table 1 and Figures 2–3, the following practical recommendations may be proposed for staged ECMO implementation in multidisciplinary hospitals:

1. Institutional readiness should be assessed before program initiation

Hospitals considering ECMO implementation should evaluate available intensive care capacity, monitoring resources, perfusion support, emergency response capability, and the feasibility of continuous multidisciplinary care. ECMO should not be introduced solely on the basis of equipment availability [2,13].

2. Initial implementation should be restricted to clearly defined indications

At the early stage of program development, ECMO use should be limited to a small number of high-priority clinical scenarios in which patient selection criteria, escalation pathways, and team responsibilities can be standardized. Broader indications should be introduced only after internal experience, case review, and procedural confidence have increased [2,3].

3. A dedicated multidisciplinary ECMO team should be established

Safe ECMO practice requires coordinated participation from intensivists, anesthesiologists, surgeons, perfusionists, nurses, and other relevant specialists. Team roles should be predefined and communication pathways formalized in order to support urgent, high-risk clinical decision-making [5,8,9].

4. Staff training should be structured and continuous

Training should include theoretical preparation, simulation-based learning where feasible, bedside mentoring, and regular review of ECMO cases and complications. Particular emphasis should be placed on nursing education because of the central role of bedside monitoring and daily circuit-related safety [5,8,9].

5. ECMO should be integrated into existing ICU pathways rather than developed as an isolated procedure

Implementation should include standardized criteria for candidate identification, escalation of respiratory or circulatory support, readiness for cannulation, anticoagulation monitoring, and management of complications. ECMO is most effective when embedded in a broader institutional system of advanced critical care [2,3,13].

6. Quality monitoring and case review should be mandatory components of program development

Hospitals should establish internal mechanisms for regular review of indications, outcomes, complications, and protocol adherence. Continuous quality monitoring is essential for both patient safety and sustainable program growth [2,13,18].

7. Program development should be aligned with regional referral logic

In healthcare systems where not all institutions can maintain advanced ECMO capability, implementation strategies should be coordinated with referral pathways, expert consultation, and collaboration with higher-level centers when needed. This is consistent with current concepts of regional ECMO networking and staged systems development [6,18].

This study has several limitations. First, it reflects the experience of a single regional center and therefore may not be directly generalizable to all healthcare settings. Second, the retrospective clinical component was descriptive and not designed to assess comparative effectiveness or identify independent predictors of outcomes. Third, the proposed recommendations were derived from a combination of international literature and local institutional experience rather than from a formal consensus process or multicenter validation study [13,18]. Fourth, ECMO implementation pathways are influenced by local infrastructure, workforce availability, referral systems, and institutional case-mix, all of which may vary substantially across hospitals and healthcare systems [5,18].

Nevertheless, these limitations do not diminish the study's practical relevance. On the contrary, combining international evidence with real-world institutional experience provides a context-sensitive framework for ECMO implementation in multidisciplinary hospitals without in-house cardiac surgery, particularly in middle-resource and organizationally transitional settings.

Conclusion

The present study shows that ECMO implementation in a multidisciplinary hospital without in-house cardiac surgery is feasible when it is approached as a staged organizational process rather than as an isolated technical intervention. The five-year experience of the Heart Center Shymkent demonstrated that sustainable ECMO program development depends not only on procedural capability, but also on institutional readiness, multidisciplinary team formation, protocolized care, workforce training, and continuous quality review [2,3,13].

The findings further suggest that ECMO services in such settings should initially focus on restricted indications and expand progressively as organizational capacity matures. As reflected in the clinical and organizational data summarized in Table 1 and in the implementation trajectory illustrated in Figures 2 and 3, program growth was associated with increased standardization, multidisciplinary coordination, and the integration of extracorporeal support into routine intensive care pathways. This supports the principle that the expansion of ECMO indications should follow, rather than precede, the consolidation of institutional competence.

By integrating international evidence with local implementation experience, this study proposes a practical, reproducible framework for the introduction of ECMO in multidisciplinary

hospitals without in-house cardiac surgery. The proposed recommendations may support safer, more sustainable, and context-appropriate expansion of extracorporeal life support in healthcare systems with limited specialized infrastructure and may contribute to the further development of regional ECMO networks [6,18].

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Author Contributions

Conceptualization: BAP, DS, and MA. Investigation: BAP, GT, SZ, and NP. Supervision: DS and MA. Methodology: BAP, DS, MA, and GT. Writing – review & editing: BAP, DS, MA, GT, SZ, and NP. All authors have read and approved the final version of the manuscript.

Conflict of interest

The authors declare no conflicts of interest.

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ШЫМКЕНТ ЖҮРЕК ОРТАЛЫҒЫНЫҢ БЕС ЖЫЛДЫҚ ТӘЖІРИБЕСІНЕН АЛЫНҒАН САБАҚТАР НЕГІЗІНДЕ КАРДИОХИРУРГИЯЛЫҚ ҚЫЗМЕТІ ЖОҚ КӨПСАЛАЛЫ СТАЦИОНАРЛАРДА ЭКМО-НЫ ЕНГІЗУ БОЙЫНША ӘДІСТЕМЕЛІК ҰСЫНЫМДАР

Түйін

Кіріспе. Экстракорпоральды мембраналық оксигенация (ЭКМО) бағдарламалары негізінен жоғары мамандандырылған орталықтарда шоғырланған, бұл көпсалалы стационарларда экстракорпоральды қолдаудың қолжетімділігін шектейді.

Мақсаты. Кардиохирургиялық қызметі жоқ көпсалалы стационарларда ЭКМО енгізу бойынша практикалық ұсынымдар әзірлеу.

Материалдар мен әдістер. ЭКМО бағдарламаларын дамытуға арналған халықаралық әдебиеттерге нарративті талдау және 2019–2024 жылдары Шымкент Жүрек Орталығында ЭКМО қолданылуына ретроспективті талдау жүргізілді.

Нәтижелері. Зерттеу кезеңінде 91 ЭКМО процедурасы орындалды. Негізгі көрсетілімдер кардиогендік шок, ауыр тыныс жеткіліксіздігі, экстракорпоральды жүрек-өкпе реанимациясы және посткардиотомиялық жүрек жеткіліксіздігі болды. 2021 жылы ауыр тыныс жеткіліксіздігі бар 12 жүкті және босанғаннан кейінгі пациентке ЭКМО қолданылды; 5 пациентте (42%) сәтті деканюляцияға қол жеткізілді. Бағдарламаның дамуы мультидисциплинарлық команданың қалыптасуымен, хаттамалардың стандартталуымен және персоналды құрылымдалған оқытумен қатар жүрді.

Қорытынды. ЭКМО-ны кезең-кезеңімен енгізу кардиохирургиялық қызметі жоқ көпсалалы стационарлар үшін қайталанатын үлгі бола алады және экстракорпоральды қолдауды қауіпсіз кеңейтуге мүмкіндік береді.

Түйін сөздер: экстракорпоральды мембрананы оттегімен қанықтыру, ЭКМО, енгізу, көпсалалы ауруханалар, кардиохирургия, реанимация, ұсыныстар.

Дәйексөз үшін: Перменов Б, Сүйгенбаев Д, Анартаева М, Тойева Г, Жунисов С, Пернебаев Н. Шымкент Жүрек Орталығының бес жылдық тәжірибесінен алынған сабақтар негізінде кардиохирургиялық қызметі жоқ көпсалалы стационарларда ЭКМО-ны енгізу бойынша әдістемелік ұсынымдар. Орта азиялық медицина гипотезасы мен этикасы журналы 2026:7(1):61-69.
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МЕТОДИЧЕСКИЕ РЕКОМЕНДАЦИИ ПО ВНЕДРЕНИЮ ЭКМО В МНОГОПРОФИЛЬНЫХ СТАЦИОНАРАХ БЕЗ КАРДИОХИРУРГИЧЕСКОЙ СЛУЖБЫ НА ОСНОВЕ УРОКОВ, ИЗВЛЕЧЁННЫХ ИЗ ПЯТИЛЕТНЕГО ОПЫТА ЦЕНТРА СЕРДЦА ШЫМКЕНТ

Резюме

Введение. Программы экстракорпоральной мембранной оксигенации (ЭКМО) преимущественно сосредоточены в высокоспециализированных центрах, что ограничивает доступность экстракорпоральной поддержки в многопрофильных стационарах.

Цель. Разработать практические рекомендации по внедрению ЭКМО в многопрофильных стационарах без собственной кардиохирургической службы.

Материалы и методы. Проведены нарративный анализ международной литературы, посвящённой развитию программ ЭКМО, и ретроспективный анализ применения ЭКМО в Центре сердца Шымкент в 2019–2024 гг.

Результаты. За исследуемый период выполнена 91 процедура ЭКМО. Основными показаниями были кардиогенный шок, тяжёлая дыхательная недостаточность, экстракорпоральная сердечно-лёгочная реанимация и посткардиотомическая сердечная недостаточность. В 2021 году ЭКМО применена у 12 беременных и послеродовых пациенток с тяжёлой дыхательной недостаточностью; успешная деканюляция достигнута у 5 пациенток (42%). Развитие программы сопровождалось формированием мультидисциплинарной команды, стандартизацией протоколов и структурированным обучением персонала.

Заключение. Поэтапное внедрение ЭКМО может служить воспроизводимой моделью для многопрофильных стационаров без собственной кардиохирургической службы и способствовать более безопасному расширению экстракорпоральной поддержки.

Ключевые слова: экстракорпоральная мембранная оксигенация, ЭКМО, внедрение, многопрофильные больницы, кардиохирургия, интенсивная терапия, рекомендации.

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