

Bioethical dilemmas in the use of extracorporeal membrane oxygenation (ECMO) support systems: a narrative review from European bioethical principles

Dilemas bioéticos en el uso del sistema de soporte con oxigenación por membrana extracorpórea (ECMO): revisión narrativa desde los principios bioéticos europeos

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Abstract

Extracorporeal membrane oxygenation (ECMO) is an advanced life support strategy used in Intensive Care Units (ICUs) for patients facing severe cardiorespiratory failure who do not respond to conventional treatments. Although its use has been shown to improve survival rates in various clinical contexts, its application raises significant ethical challenges, particularly when the prognosis is uncertain or the chances of recovery are slim. This makes it essential to carefully assess the appropriateness of the procedure and consider the possibility of limiting therapeutic effort in order to avoid prolonging human suffering.

The European bioethical principles (vulnerability, dignity, integrity and autonomy) present a contextualized approach, considering the fragility of the critically ill patient, the importance of preserving well-being and the recognition of dignity especially at the end of life.

Keywords: bioethical dilemmas, extracorporeal membrane oxygenation, bioethical principles, dignity, integrity, autonomy, vulnerability.

1. Introduction

Thanks to technological advances, new medical therapies have been introduced in Intensive Care Units (ICUs) that can prolong the lives of critically ill patients. Among these is extracorporeal membrane oxygenation (ECMO), a technique developed in the 1960s as an evolution of the cardiopulmonary bypass (CPB) machine, designed to provide prolonged cardiorespiratory support in cases of heart or lung failure that do not respond to conventional medical treatments (1); however, its ability to maintain vital functions does not always guarantee meaningful recovery. This raises profound ethical questions related to the limits of treatment, prolonged suffering, and dignity at the end of life.

There are two main modalities of ECMO support, as shown in Table 1. Veno-venous ECMO (VV ECMO) is used specifically to provide respiratory support in patients with severe pulmonary failure, while Veno-arterial ECMO (VA ECMO) provides both cardiac

and respiratory support in cases of cardiogenic shock or refractory cardiorespiratory arrest (2). These techniques are typically used in patients with potentially reversible conditions when other conventional therapies have failed (1,3).

Table 1. Indications for ECMO Support

Support	Instructions	Contraindications	Complications
ECMO VV	Severe ARDS ($\text{PaO}_2 < 50$ mmHg for 3 hours), $\text{PaO}_2/\text{FiO}_2 < 80$ mmHg for 6 hours, arterial pH less than 7.25, PaCO_2 greater than 60 mmHg.	Multiple organ failure Poor short-term prognosis (metastatic disease), advanced-stage comorbidities, and devastating neurological conditions (massive hemorrhage).	Thrombosis and hemorrhage: Intracranial hemorrhage, hemolysis, thrombocytopenia.
ECMO VA	Cardiac arrest (extracorporeal CPR), cardiogenic shock secondary to acute coronary syndrome, acute heart failure, right or left ventricular failure, post-cardiotomy inability to wean off bypass, primary graft failure in heart transplantation, myocarditis, refractory ventricular arrhythmias, severe hypothermia ($< 28^\circ\text{C}$) with hemodynamic instability, and septic cardiomyopathy.	Unwitnessed cardiac arrest, severe aortic insufficiency, severe and irreversible multiple organ failure, severe and irreversible brain injury, widespread malignant disease, aortic dissection, peripheral arterial disease, and low probability of myocardial recovery.	Thrombosis and ischemia in extremities, hemolysis, acute kidney failure.

Source: prepared by the authors, adapted from the General Guidelines for All ECLS Cases, Extracorporeal Life Support Organization (ELSO), 2017.

In certain situations, ECMO can become what is commonly referred to as a “bridge to nowhere” (2). This occurs when clinical recovery, transplantation, or transition to another therapeutic modality are not feasible (4,5). In such circumstances, ECMO ceases to be a therapeutic tool and becomes a source of significant ethical conflict. The dilemma lies not only in deciding when to initiate this support but also in identifying the appropriate time to limit or withdraw it, prioritizing the patient’s dignity and well-being over goals focused solely on prolonging biological functions (6,7). In this context, bioethics plays a fundamental role as a guide for clinical decision-making related to ECMO.

A narrative literature review was conducted to analyze the main bioethical dilemmas associated with the use of the ECMO system from the perspective of European bioethical principles. This type of review was considered appropriate for integrating clinical, ethical, and regulatory perspectives, as well as for contextualizing decision-making in highly technologically complex scenarios. The review included original articles, narrative and systematic reviews, consensus documents, clinical guidelines, and bioethical analyses published in peer-reviewed journals that explicitly addressed the use of ECMO in critically ill patients and its ethical implications.

The information was organized thematically, identifying the main bioethical dilemmas linked to the indication, continuation, and discontinuation of ECMO.

This article proposes incorporating European bioethical principles —such as vulnerability, dignity, integrity, and autonomy— as established in the Barcelona Declaration and elaborated by Torralba, as a complementary alternative to principlism (9). These principles offer a more comprehensive approach to addressing the moral complexity inherent in the use of ECMO, especially in situations with uncertain prognoses or when considering limiting therapeutic efforts.

2. Ethical and bioethical dilemmas in ECMO

Ethics is the branch of philosophy that examines voluntary and conscious human actions, evaluating them in terms of whether they are morally acceptable or unacceptable within a specific social context. In the field of healthcare, medical ethics guides clinical decisions, while deontology establishes the norms and duties that govern relationships among healthcare personnel, patients, and society (9,10). Bioethics, on the other hand, emerges as an applied discipline that extends this reflection to the fields of life sciences and biomedicine. Its purpose is to analyze and provide normative frameworks for addressing dilemmas arising from advanced medical technologies, especially when these affect the beginning, maintenance, or end of human life (11,12). An ethical dilemma is a situation in which professionals are confronted with conflicting moral principles or ethical norms, where no single decision can satisfy all the implicit values (13). A contemporary example in this field is the use of ECMO, a technology that operates on the borderline between potential recovery and the artificial prolongation of the dying process.

The use of ECMO is a measure typically implemented in urgent situations, amid diagnostic uncertainties, and sometimes under high emotional pressure, where the impulse to “do everything possible” could overshadow a more measured ethical assessment (5). In these contexts, ECMO not only sustains physiological functions but also sustains hopes and, at times, unrealistic expectations regarding recovery (6).

The bioethical framework began to take shape in the United States following the Belmont Report (1974), which established the foundational principles of autonomy, beneficence, and justice to govern research involving human subjects (11). Years later, Beauchamp and Childress expanded this framework to the bioethical “four principles” by incorporating the concept of non-maleficence. These principles have guided clinical practice for decades, forming

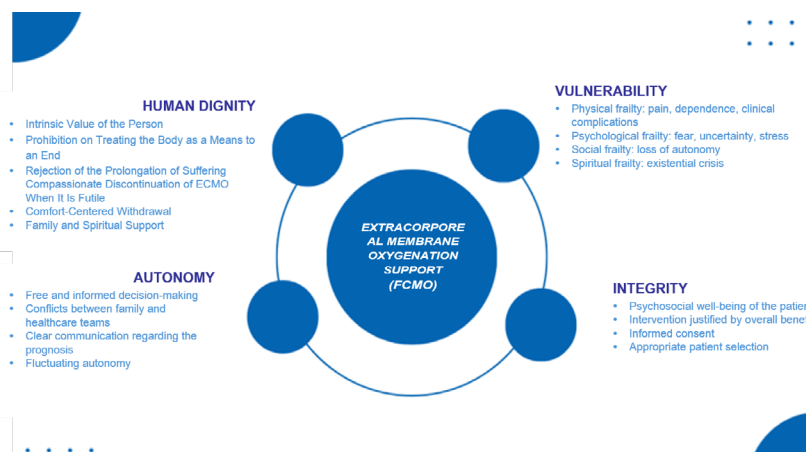
an important foundation for medical decision-making (12,14). However, the traditional “four principles” face challenges in complex and highly technified clinical scenarios. This is particularly relevant in cases such as patients undergoing ECMO treatment in situations with an uncertain or unfavorable prognosis (15). The lack of a clear hierarchy among the principles and their predominantly individual-centered approach make it difficult to resolve tensions between patient autonomy, the clinical decisions of the medical team, and the emotional and social repercussions arising from therapeutic decisions (16). This tension becomes evident in cases where ECMO ceases to be a bridge to recovery or transplantation and instead becomes a “bridge to nowhere” (8,17,18). In these circumstances, extracorporeal support may prolong biological life without offering a reasonable prospect of functional recovery, leading to a scenario of therapeutic futility, which causes profound physical, psychological, and moral suffering for the patient, their family members, and even the healthcare team in charge.

One of the greatest ethical dilemmas lies not so much in deciding when to initiate ECMO, but rather in identifying when prolonging its use is no longer ethically justifiable. Unjustifiably extending the use of ECMO in cases of medical futility can lead to futile medical treatment, understood as the continuation of a disproportionate intervention that prolongs suffering without offering any real benefits (19). Faced with this dilemma, key questions arise regarding the limits of traditional ethical principles: how to respect autonomy in patients who are unconscious or unable to participate in decision-making; when the intent to benefit becomes harmful; whether it is morally correct to maintain advanced life support simply because it is technologically possible; and what impact the moral burden faced by the medical team has when making these decisions (2,18,20).

In Europe, this type of analysis gave rise to the bioethical principles of vulnerability, dignity, integrity, and autonomy enshrined in the Barcelona Declaration in 1995 (12). Subsequently, authors such as Torralba, Rendtorff, and Kemp expanded these concepts to adapt them to European cultural particularities and address the ethical

challenges associated with the growing use of biomedical technologies (14). In the case of ECMO, European principles provide relevant tools by focusing not only on the technological or medical aspects of treatment but also on the human and contextual dimensions necessary for a more comprehensive ethical evaluation, as shown in Figure 1.

Figure 1. European bioethical principles



Source: author's own work.

3. Vulnerability

The principle of vulnerability expresses the finitude and the physical and existential fragility of human beings in the face of illness, a fragility that is magnified in the case of critically ill patients on advanced life support, whose lives are biologically sustained by technology (4); within the context of ECMO, this vulnerability transcends the biological realm, also encompassing the psychological, social, and moral dimensions in the face of illness; the principle of respect for vulnerability calls for restoring the natural balance of the human body (18).

Absolute dependence on invasive technology, coupled with the inability to communicate and the loss of control over one's own body, places the patient in a position of maximum ethical exposure (18). In European bioethical principles, vulnerability is placed at the core of moral reflection, recognizing that not all individuals have the same opportunities to exercise their autonomy (19,20).

This perspective is particularly relevant for patients on ECMO, most of whom are sedated, intubated, or experiencing impaired consciousness that limits their ability to actively participate in decisions regarding their treatment (21). From this perspective, vulnerability requires the healthcare team to assume an even greater ethical responsibility, in which healthcare personnel act as temporary custodians of the patient's values and wishes, bearing the duty to make decisions that strike a balance between potential benefits and the risk of perpetuating suffering (4).

Vulnerability, therefore, should not be interpreted as a justification for making arbitrary, paternalistic decisions; rather, it implies a commitment to prudence, ethical deliberation, and active protection of the person's dignity (22). Similarly, vulnerability also affects families, who face extremely complex decisions under an enormous emotional burden and with limited technical knowledge. The uncertainty surrounding the prognosis of ECMO can fuel unrealistic expectations of recovery, making it difficult to accept therapeutic limits (18,21,23). In this context, bioethics emphasizes the importance of transparent, honest, and empathetic communication that allows family members to understand that technology does not always guarantee recovery and that providing end-of-life support is also a meaningful and legitimate form of care (21,23).

4. Integrity

The principle of integrity refers to the wholeness of life, which must not be destroyed; it implies respect for privacy and the patient's understanding of their own life and illness—not merely as a biological

organism, but as a being with an identity, history, values, and meaningful relationships (9,19). Within the context of ECMO, this principle takes on special importance due to the invasive nature of the treatment; this procedure involves cannulation of large vessels, connection to extracorporeal circuits, and constant interaction with the patient's body (23).

The experience of bodily fragmentation endured by a person undergoing ECMO can be reflected in a symbolic rupture of their personal integrity. The body becomes an object of continuous technological intervention, with the focus centered on physiological parameters such as flow rates, pressures, and blood gas levels, pushing the human dimension of care into the background (23); this dynamic underscores how technology-driven care can shift the clinical focus toward the machines, overlooking the fact that the true subject of care remains the patient connected to them.

From a bioethical perspective, preserving the patient's integrity requires recognizing the limits of medical intervention and assessing whether prolonging the use of ECMO support remains proportionate to the expected benefit (24,25). If treatment ceases to contribute significantly to recovery or the alleviation of suffering, its unnecessary prolongation could compromise the patient's overall well-being (26); ensuring integrity is also closely linked to decisions regarding the limitation or withdrawal of ECMO (27,28).

These decisions do not constitute therapeutic abandonment; on the contrary, they can be understood as an act of respect for the person. By choosing to avoid excessive treatment, a transition to care focused on comfort and dignity is made possible (21,29). Determining the appropriate time to discontinue extracorporeal support requires both technical knowledge and an ethical sensitivity that goes beyond the mere pursuit of preserving biological functions (23).

Finally, the principle of integrity also encourages the medical team to question its own professional practice. Constant exposure to extreme situations, the pressure inherent in managing advanced technologies, and the emotional burden associated with end-of-life decisions can lead to significant moral exhaustion (28). Recognizing

the importance of healthcare professionals' integrity involves fostering spaces for ethical reflection, institutional support, and interdisciplinary collaboration, thereby helping to maintain a more humane and mindful clinical practice even in highly technological settings (6).

5. Autonomy

The principle of autonomy recognizes each person's right to make free and informed decisions regarding their health, in accordance with their own values, beliefs, and personal preferences (30).

In the ECMO setting, this principle faces serious challenges, as many patients who could benefit from this therapy are often in critical condition, sedated, or experiencing impaired levels of consciousness (24). These conditions make it difficult or even impossible to uphold the principle of respect for autonomy (21,23). In such situations, the responsibility for decision-making generally falls to legal representatives or family members, who assume the role of surrogate decision-makers (21,27).

This model of surrogate autonomy presents profound ethical dilemmas, especially when there are no advance directives or when the patient has not previously expressed their wishes. In such situations, the medical team must strive to interpret the patient's wishes, considering their personal history, values, and beliefs, and ensuring that decisions are not guided exclusively by the wishes or fears of family members (2, 30).

One of the most common errors in clinical practice is assuming that mere access to technology implies a moral obligation to use it. From a bioethical perspective, respecting patient autonomy does not necessarily mean initiating or continuing ECMO treatment but rather ensuring that the decisions made reflect what the patient themselves would have considered acceptable for their life (23,27). In this context, informed consent should be understood as a flexible and ongoing process, reevaluated as the patient's clinical condition

evolves, rather than as a one-time action at the start of the procedure (21, 22).

The high technical complexity of the treatment and the inherent uncertainty regarding its prognosis require transparent, sincere, and empathetic communication between the medical team and family members (21), as well as the involvement of the bioethics team to address interdisciplinary conflicts. This approach facilitates shared decision-making that reduces the emotional and moral burden on family members, while promoting decisions that reflect the patient's best interests, especially when considering limiting or withdrawing extracorporeal support (26,29).

6. Dignity

Dignity is an inherent quality of every person, regardless of their health status, level of consciousness, or prognosis (28,29). In the case of ECMO use, this value is particularly compromised due to the invasive nature of the therapy, its complete dependence on technology, and the risk of prolonging biological life without guaranteeing the patient's well-being and sense of purpose (31).

European bioethical principles place dignity at the center of moral decision-making, recognizing that human life transcends the mere preservation of physiological functions (20). ECMO technology can maintain heart function and gas exchange processes, but it does not always succeed in restoring a life that the patient themselves considers worth living (23,33). In these circumstances, prolonging the use of life support could become an avoidable source of suffering.

Respecting the dignity of a patient on ECMO involves recognizing the limitations of medicine and identifying the moments when discontinuing support becomes an ethical course of action, especially if it no longer provides benefits (23,32,33). Such withdrawal should not be interpreted as abandonment, but rather as a decision

based on respect for the individual (34). This approach takes on particular relevance in debates regarding the limitation of therapeutic efforts, since the withdrawal of ECMO can facilitate the transition to palliative care, which focuses on providing comfort, alleviating suffering, and accompanying the patient in their final days (21,33).

Dignity is also reflected in the care provided to the patient while on ECMO support; respectful treatment, protection of privacy, adequate pain management, and addressing the patient's emotional and spiritual needs are essential aspects of dignified care (33,34). Even when the patient is unable to express themselves, the medical team's attitude toward them must demonstrate recognition of their value as a human being (21,31). Finally, preserving dignity calls on health-care systems and professionals to evaluate the responsible use of highly specialized resources. Distributive justice, although not always explicitly stated in European principles, is deeply linked to dignity, especially when questioning the allocation of costly technologies in cases of medical futility, particularly in contexts where resources are limited (31,35).

Conclusions

The use of ECMO represents one of the greatest advances in contemporary critical care medicine; however, its implementation raises complex ethical dilemmas that transcend the technical dimension of life support (24). This review highlights that, although ECMO has been shown to improve survival in selected patients (23), its application in scenarios with an uncertain or unfavorable prognosis requires in-depth ethical reflection aimed at avoiding futile medical treatment and preserving human dignity.

International literature agrees that decisions regarding the initiation, maintenance, and withdrawal of ECMO are marked by a high degree of clinical and moral uncertainty. The ability to prolong biological functions does not eliminate the vulnerability of the critically ill patient, nor does it guarantee favorable outcomes.

European bioethical principles acknowledge the critically ill patient's state of extreme fragility, the invasiveness of the technology, and the need to preserve the whole person beyond mere biological survival (35). One significant aspect identified is the moral burden faced by healthcare professionals involved in the care of ECMO patients; the pressure to maintain advanced technologies, combined with prognostic uncertainty and family expectations, can lead to emotional strain and moral suffering. In this context, bioethics not only guides clinical decision-making but also helps protect professional integrity through shared ethical deliberation, interdisciplinary collaboration, and institutional support (25).

In this regard, the limitation or withdrawal of extracorporeal support, when it ceases to be proportionate, should not be interpreted as a therapeutic failure but rather as an expression of ethically grounded care (30,34); only through a balanced integration of technical knowledge, ethical reflection, and human sensitivity will it be possible to ensure the appropriate use of ECMO.

One limitation of this review is that it did not follow a systematic methodology, which may restrict the generalizability of its conclusions.

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