Editorial

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Ethical considerations on the role of artificial intelligence in defining the futility in emergency surgery

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Medicine is complex and physicians all over the world struggle everyday with rising patient volumes and increasing complexity of diseases, despite a persistent shortage of resources[1]. Artificial intelligence (AI) emerges as a powerful ally in addressing these challenges in this scenario[2-4]. The integration of AI in medicine is driven by its unparalleled ability to analyze vast amounts of data quickly and accurately, thereby enhancing diagnostic precision, personalizing treatment plans, and optimizing operational efficiencies[5-7].

AI appeared in medicine several decades ago, rooted in the foundational principles of computer science and early explorations into machine learning (ML). The initial forays into AI in the medical field can be traced back to the 1950s and 1960s[8-10]. During this era, pioneers like Alan Turing[11] laid the groundwork with theoretical concepts, while researchers began experimenting with rule-based systems and early forms of decision support[8,10,12]. But it was not until the 21st century, that AI began to truly transform medicine with the advent of big data, more powerful computing resources, and significant breakthroughs both in ML and deep learning (DL)[13]. Algorithms capable of processing vast amounts of medical data became feasible, quickly and accurately[14]. This enabled more precise diagnostics and personalized treatment plans[15]. Moreover, it enhanced patient monitoring[8,10].

Although the enormous efforts put in place, despite all the progress made and the fact that nowadays AI is gaining a pivotal role in the medical field, some general aspects are yet to be addressed[15,16]. Much is to be discussed on how AI should play its part when it comes to the bioethical side of the medical practice[17]. We believe that it seems useful, therefore, to analyze the relationship between AI and futility in medicine, particularly regarding general and emergency surgery. This paper does not have the ambition to give a precise and encyclopedic portrait of AI; to move further with our discussion we believe it is necessary to understand how AI is intertwined with the medical field and more specifically with the surgical practice.

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AI in surgery

If we were to give a definition of AI, we could all agree that it is the capability of a machine to imitate intelligent human behavior[18]. This superficial and minimal definition appears to be unfit for the tasks we are about to address. We need to dive deep in the nature of AI to understand its appliances in medicine. AI is to be considered an umbrella term encompassing many forms of computer engineering technologies which enable algorithms to learn from, interpret, produce predictions from and act on different data autonomously[19]. Amongst all the different technologies available, one can rely on the following in the medical and surgical field: image processing and computer vision, artificial and convolutional neural network, ML and DL[20,21]. With the introduction of these advanced technologies, healthcare professionals – surgeons in particular – can now harness vast amounts of healthcare data to guide decision-making in clinical practice[22-24]. This data could be employed preoperatively to optimize patient selection and preparation, intraoperatively to improve procedural outcomes and operating room efficiency, and postoperatively to reduce complications, lower mortality rates, and enhance follow-up care[25,26]. The strength of these AI tools lies in their ability to analyze complex datasets from electronic health records, integrating diverse information to identify patterns and correlations. This process transforms large datasets into actionable insights, enabling the creation of predictive models that significantly enhance the quality of clinical decision-making[27,28].

The current use of AI in surgery is still in its early stages, and we are just beginning to explore the full potential it offers to surgeons. While there are still relatively few studies confirming its efficacy, promising advancements in the AI-surgeon interface are already visible across several key areas of surgical practice, such as perioperative, intraoperative and futility[1,2,21,29-31]. There are multiple examples where AI significantly improves diagnostic accuracy. One notable case is the RadioLOGIC algorithm in breast surgery and the diagnosis of breast cancer[32].

The existence of tools to calculate the surgical risk is desirable for surgeons who have to estimate the risk of morbidity and mortality before an operation. For this purpose, a decision tree model was created by the Massachusetts General Hospital and Harvard Medical School and an application, Predictive OpTimal Trees in Emergency Surgery Risk (POTTER), was then designed. It considers 18 possible complications and demonstrated a quite high accuracy in detecting 30-day postoperative complications (0.7358 50% was 0.953 instead)[10]. POTTER was then validated in 2021. It confirmed a high predictive value: morbidity and mortality had a c-statistic of 0.77 and 0.86, respectively. Moreover, it had particularly promising results in predicting some specific complications such as septic shock and respiratory failure[8]. The same institution developed also another smartphone tool aiming to predict in-hospital mortality and complications both for penetrating and blunt trauma patients. Trauma Outcome Predictor is a nonlinear risk calculator which considers demographics, vital signs and trauma mechanism with a high predictive value for penetrating trauma (0.95) and slightly lower for blunt trauma (up to 0.8)[12].

Other ML models are based on patient electronic health records (EHR). There are 42 EHR models with a good predicting value (AUC 0.747-0.924). They include penalized logistic regression, random decision trees and random forest. The first two seem to have better outcomes compared to random forest models. All the models calculate the risk score for 14 different complications on data referring to demographics, comorbidities and procedure. The studied complications included, among the others, 30-day mortality, shock and sepsis[18]. Another AI model for predicting mortality was developed by a Korean trauma center and included the following variables: age, sex, intentionality, injury, emergent symptom, Alert/Verbal/Painful/Unresponsive (AVPU) scale, Korean Triage and Acuity Scale (KTAS), and vital signs. It revealed to be a good predictive model and showed that the two most influent variables were age and unresponsiveness[19]. A gradient boosting model was also used to predict mortality at triage level in order to optimize the waiting list in the Emergency Department and the resources, but it is not specific for urgent surgical conditions[20]. We believe that these tools could be very helpful for the surgeons, but they are still to be validated to be used in clinical practice on a large scale. Moreover, the operating room is the heart of surgical practice, characterized by a data-rich environment with continuous monitoring of physiological parameters and complex changes in anatomy and physiology. The introduction of robotic and minimally invasive surgery has facilitated the integration of AI in the operating room[33]. AI-enhanced image processing and analysis during surgery, along with real-time machine segmentation and augmentation, are assisting surgeons in performing more precise and efficient procedures[24]. This not only leads to more accurate surgeries but also reduces morbidity and mortality[28,34].

The possibilities of AI to revolutionize and improve the healthcare system are limitless[35]. Increased investments are expected through the partnership of technology companies with healthcare organizations, which would lead to changes and improvements in the way healthcare is delivered. In this context, especially in countries like Italy where the right to health is a right enshrined in the Constitution (Art. 32), it is necessary that access to the potential of AI is uniform throughout the national territory[36]. Therefore, the action of a specific National Agency that controls the use of AI in medical care and research appears necessary, to overcome the weakness of the Italian healthcare system which is fragmented into 20 regional systems. This fragmentation not only disappoints the Italian population but also imposes a significant economic burden on the country, with a healthcare migration from the regions with limited resources in the South of the country to the better equipped hospitals in the Northern regions. The economic data are unequivocal: a system with the critical issues of financing and planning such as the Italian healthcare system presents the risk to be no more universalistic. On the other hand, an analysis of the UK National Health System (NHS) has shown how chronic underfunding can only lead to the implosion of a previously well-functioning health service[37]. This data should not be underestimated because the Italian system is inspired precisely by the NHS model.

Futility

Having observed the numerous applications of AI in the surgical field, it may seem that AI has resolved all the challenges. However, when one approaches the boundaries of established guidelines, considers the ethical and moral aspects of the medical profession, and particularly when confronted with difficult decision-making[38-40], it becomes evident that AI still has significant limitations. One major area of concern is surgical futility and how AI might play a role in addressing this complex and delicate issue. There is little work in emergency surgery futility[41]. A recent literature review found only three publications. These papers reported the results of 105 157 patients, of which only 1114 patients had undergone futile surgery[42].

The incidence of elderly patients with multiple comorbidities presenting for emergency surgical evaluation is rising, steadily. Although the general mortality rate for surgical interventions spans 1.5% to 9.8%, mortality rates following emergency laparotomy in individuals aged 65 and older are estimated between 15% and 44%, with considerable variation linked to perioperative conditions[43-46]. A recent study documented that the adoption of a national mortality audit to avoid futile surgery resulted in a reduction in mortality after emergency laparotomy in Australia[47]. These findings raise essential considerations regarding whether procedural indications in critically ill patients prioritize quality of life or merely extend survival. In the context of critical illness, indications for emergency laparotomy may lead surgeons toward interventions potentially classified as futile. Here, futility represents an ineffective clinical effort that exacerbates patient and family distress and significantly increases healthcare expenditure[48-50]. However, determining the futility of an intervention poses a complex and nuanced clinical dilemma, necessitating careful evaluation of both patient-centered outcomes and resource utilization[50].

Since the beginning of medicine, futility has been a pivotal issue of the clinical practice. Hippocrates, defined good medicine as "doing away with the suffering of the sick, lessening the violence of their diseases, and refusing to treat those who are overmastered by their diseases, realizing that in such cases medicine is powerless"[48,51,52]. For many centuries, it was not difficult to adhere to these commands when medicine operated under a paternalistic model, making all decisions on behalf of patients. In this context, the limited available tools had little impact on the prognosis of critically ill patients. It was only in the 20th century, with technological advancements and progress in the medical sciences, that it became possible to positively influence the life expectancy of patients, including those with terminal conditions, making futility a real issue[53]. Consequently, between the 1980s and 1990s, there was a growing interest on this topic, which is still very debated[52].

The initial concepts of futility are grounded in the ethical principle of beneficence, which guides physicians to prioritize interventions that provide more benefit than harm to the patient. In clinical evaluations, beneficence hinges on whether a proposed treatment has a reasonable chance of offering a meaningful health benefit to the patient[54]. It follows that the term futility encompasses various nuances of interest[29]. In fact, we discuss physiological futility when it is believed that an intervention is unlikely to produce a physiological benefit[55] or clinical futility. The latter encompasses two different aspects, a quantitative aspect (e.g., a medical treatment that has proven useless in a significant number of patients) and a qualitative aspect, when any treatment is limited to preserving permanent unconsciousness and fails to end a patient's total dependence on intensive medical care[52,56]. Furthermore, an intervention is to be considered futile when the patient is reliably expected to die without recovering consciousness before discharge (imminent demise futility)[57] otherwise when it is likely that the quality of life will be unsatisfactory for the patient following the proposed treatment (qualitative futility)[55].

All four dimensions of futility must undergo thorough assessment prior to any clinical decision involving the inclusion or exclusion of a specific treatment. This evaluation presents a spectrum of ethical and moral challenges, rendering clinical decision-making a highly complex and intricate process[58-61]. Surgeons are often positioned at the intersection of clinical guidelines, evidence-based best practices, patient autonomy, and family input – factors that may conflict in determining the most favorable approach for patient care.

In the Catholic perspective, the debate on medical futility considers respect for patient autonomy, on the one hand, and physician beneficence and distributive justice, on the other. In seeking a balance between the values and goals of the patient and the values and goals of medicine, individual autonomy cannot be so inflated in importance as to destroy the principle of charity and neglect the equitable distribution of medical resources in society. To find the balance, physicians must reach a consensus on what constitutes reasonable medical treatment, and patients and surrogates must limit their self-advocacy to what is just and fair for all[62]. The reasonable treatment decision must focus on the best interests of the patient, without failing to recognize that everyone is also a member of society. The justification of medical treatments based on the assessment of benefits and the appropriate use of medical resources is rooted in the Catholic moral tradition, firmly. It distinguishes between ordinary and extraordinary means. Various Church documents make clear that individual autonomy is not absolute. Pope John Paul II applied this principle to medical treatments in Evangelium Vitae when he stated: "There is certainly a moral obligation to take care of oneself and to allow oneself to be treated, but this duty must take into account the concrete circumstances. It must be established whether the available means of treatment are objectively proportionate to the prospects of improvement"[63]. Catholic culture holds that if a medical intervention is judged ordinary, that is, if it offers a reasonable hope of benefit to the patient and could be used without excessive inconvenience, including risk, pain and expense, it is considered morally obligatory. If it offers no reasonable hope or benefit or is excessively burdensome, it is extraordinary and is morally optional. Pius XII further clarified the distinction between ordinary and extraordinary means on the idea that human life is a fundamental good, but a good to be preserved precisely as a necessary condition for the existence of other values[64]. We believe that it is necessary to investigate whether and how AI could help doctors, especially surgeons, in the field of bioethics, to manage end-of-life care and make informed therapeutic decisions.

AI and bioethics in healthcare, surgery and futility

World Health Organization has worked with a leading group of 20 experts to identify core principles to promote the ethical use of AI for health[65]. The six proposed key points are particularly oriented to protect autonomy, promote human well-being, ensure transparency, explainability and intelligibility, foster responsibility and accountability[65]. They favor inclusiveness and equity, allowing AI to be responsive and sustainable. Moreover, they would represent the basic criteria to achieve an ethical use of AI in the field of health and medicine.

Certain AI decisions may be replete with uncertainties, especially if medical doctors themselves are uncertain about the "right" decision, especially in the surgical rooms where peculiar ad hoc decisions are frequently made[66]. While AI can offer unwelcome surprising suggestions that can help the surgeon to make difficult decisions, in other circumstances AI may decide that the mission is impossible, and the surgery will be futile. It may choose not to save the patient, then. AI finds application in critical healthcare settings, for example to help patients reflecting on the choice of their DNAR (do not attempt resuscitation) status or physicians to deliberate if resuscitation would reflect an incapacitated patient's will[67]. It does not have decisional authority and should never replace conversations with the patient, legal representatives or within the treatment team. The system can act as a conversation prompter, tie breaker or second opinion. It may invite self-critical reflection of the physician in charge or possibly of relatives and even patients. It may act as a support tool in case no information about a patient's will is available. AI-based algorithms, given appropriate training data, could also predict under what conditions (if any) this choice would change, for instance when the likelihood for survival drops below a certain value. In this scenario, the outcome-based preference predictions would then be compared with the likely outcomes (possibly also predicted by an algorithm) for an individual patient, and the code status adjusted accordingly[67].

AI has no humanistic interactions or perceptions such as eye contact, authenticity, creativity and love. It cannot consider the pain psychological aspect[66]. Culturally, AI sets the risks of eroding humanism in healthcare, threatening patient-physician synergy (although, with the assistance of AI, physicians will have more free time to interact with their patients). Professionally, AI may deskill physicians and jeopardize their jobs.

Equally important is the respect for the patient's choices and autonomy. In a systematic review of 2023[68], authors focused on the role of AI for clinical ethical decision making, especially if patients are not able to express their opinion. The proposed applications of AI would result in more accurate predictions than existing methods. Thereby, they would increase the chances that decisionally incapacitated patients receive the treatments they want and avoid the treatments they do not want. This is fundamental in the numerous cases lacking an available and relevant pre-existing directive, since the alternative strategy of surrogate-supported decision-making often fails to provide treatment consistent with the patient's preferences. On the other hand, information supplied by AI may not be as robust as one might think, since even well performing algorithms can be unreliable in individual cases. The algorithms on which the tools are based may never be fully comprehensive of the actual ethical decision-making process and AI is thought to lack the ability to act empathetically.

The concepts of human dignity and sanctity of life imply that the application of information technology in medicine must be *beneficent and non-maleficent* for the individual patient. However, the use of AI based on cohort studies and applied to individual patients could trigger futile, i.e., potentially inappropriate interventions. A way to solve this dilemma is to personalize probabilities as much as possible, e.g., by considering more features describing the circumstances of the individual patient[68,69]. AI technologies should not harm people. The designers of AI technologies should satisfy regulatory requirements for safety, accuracy and efficacy for well-defined uses, cases or indications. Measures of quality control in practice and improvement in the use of AI over time should be available. Preventing harm requires that AI does not result in mental or physical harm that could be avoided by the use of an alternative practice or approach[65].

Most ML algorithms suffer from lack of transparency. They are rather "black boxes" (more so for the end users than the developers) where the input data goes through many layers of deep neural networks and the analysis is completed without revealing the intermediate steps or chain of predictions[66]. Therefore, doctors are not always able to understand, interpret and explain these algorithms and informed consents have their hitches. Transparency helps to improve the field, foster trust, reduce damages, clarify matters for legal issues, and fulfill principles of democracy. Transparency can be addressed by providing source codes, used data, lists of limitations, and potential consequences and using nontechnical terms to bridge between the developers, investors, service providers, and the end-users of AI[70,71]. The use of blockchain in healthcare also helps transparency and provides a clear audit trail for AI decision-making. A blockchain network in healthcare is also useful for securing accounting management, exchanging patient data, and for avoiding serious mistakes[66]. Some scientists recommend sacrificing the power of AI models in favor of explicability to foster social trust and prevent domination by unaccountable models or algorithms[58].

Humans require clear and transparent specifications of the tasks that systems can perform and the conditions under which they can achieve the desired performance. Although AI technologies perform specific tasks, it is responsibility of the stakeholders to ensure that they can perform those tasks, and that AI is used under appropriate conditions and by appropriately trained people. Responsibility can be assured by application of "human warranty," which implies an evaluation by patients and clinicians for the development and deployment of AI technologies. Human warranty requires application of regulatory principles upstream and downstream of the algorithm by establishing points of human supervision. If something goes wrong with an AI technology, there should be accountability. Appropriate mechanisms should be available for questioning and for redress for individuals and groups that are adversely affected by decisions based on algorithms[65].

The use of AI/ML clinical decision support systems holds great promise for debiasing surgical decision making[72]. The system could provide an objective, accurate, and individualized assessment of surgical risk based on information from the patient's medical record rather than subjective appraisals[73]. Furthermore, the system would not be affected by concern for reported outcome metrics that might otherwise bias surgical judgment. Finally, the system could track not only the patients accepted for surgery but also those declined for surgery, thus providing a mechanism for recognizing biased trends. AI/ML systems could be associated with perpetuating rather than resolving bias. One way to debias AI is by carefully examining the assumptions the algorithm uses to make predictions and the data on which the system is trained. For AI/ML clinical decision support systems to debias patient selection for major surgery, race-associated outcomes should be assumed to be based not solely on inherent patient risk but on inequitable health care structures as well[74].

The principle of justice deals with the distribution of resources within a society and non-discrimination of individuals. Non-intentional injustice to individuals has become an important issue for AI. Ranking algorithms can perpetrate inadvertently cultural biases and determinate source of discrimination. For example, algorithms may assign a low chance of survival to previously disadvantaged patient groups whose social status had correlated with a discriminatory biomarker, e.g., body weight[58,75]. A possible approach to prevent already recognized biases is to exclude certain parameters, such as age or gender, from the training of AI models. Importantly, this is a conscientious decision within the society that introduces new biases and might also be associated with a price to pay, such as a substantial reduction of model performance and, therefore, its usability. Conflicts may occur between the different levels of justice (societal vs. individual) and could eventually violate the respect for patients' autonomy[58].

AI and green bioethics

Healthcare emits a significant amount of carbon in many countries[76]. The environmental impact of healthcare has been under considered, in part, because of the assumption that all available healthcare technologies are medically necessary and therefore carbon emissions are morally irrelevant[77]. In the USA, approximately 8% of carbon emission comes from the health care system[78]. Currently, multiple organizations in different countries are promoting climate-friendly healthcare[76,79]. With the advent of AI, the environmental impact of healthcare is increasing[80]. Carbon emissions from AI use appear throughout the lifecycle of programming, development, and use due to the high energy and resource demands of AI.

The current environmental crisis has largely been ignored by traditional biomedical ethics, hence, green bioethics emerged from the pressing need for a coherent ethical framework for sustainability in health care. Green bioethics, developed by Richie[77], offered four principles for assessing the environmental sustainability of medical developments, techniques and procedures, fundamentally based on distributive justice, to mitigate the huge disparities in healthcare delivery, on resource conservation, because human healthcare needs should take priority over human healthcare desires and the expansion of healthcare needs will not conflict with environmental conservation if health care desires are limited, on simplicity, implementing disease prevention and a stepwise approach to medical interventions, and on ethical economics, where humanism should guide healthcare developments before profitability. A sustainable development of AI in healthcare may include, for instance, triage algorithms in emergency rooms. The algorithm could facilitate equity in waiting times, which would uphold the biomedical principle of justice. A sustainable use of AI in healthcare may include, for instance, analyzing rich text data to detect emerging outbreaks with novel symptom patterns or identifying patterns of infection[81]. This use of predictive analytics can prevent outbreaks, which would support the health of populations. Such use of existing AI may harness data on patterns of infection to deliver rapid treatments, which would ensure biomedical justice for patients expecting timely care[5].

Conclusion

The relationship between technology and ecology will be a defining feature of biomedicine in the 21st century: by utilizing the criteria of health, justice, and resource conservation the goals of medicine are ethically supported[82]. In a nutshell, AI must be implemented only under the surveillance of human intelligence in medical, legal, and cultural contexts, which is still a long way away from now[66]. With AI development/implementation, ethical concerns will further elaborate in numbers and severity. Updated legally binding regulations and legislative norms need to be issued as traditional laws would no longer be suitable for scenarios where AI machines make fully or partially autonomous decisions[66].

Ethics must be embedded as early as the research stages and at practical levels. Solutions already implemented, currently at a nascent stage of development, or to be considered in the future are incorporated in this section. Before allowing its implementation in medicine, an AI model must prioritize the benefit of patients by design and protect their emotional fulfillment. It should encompass best clinical practice, be transparent, and fulfill privacy laws and cultural norms. In addition, AI models have to adhere to existing rules and regulations. They should be strictly rejected if they have the potential to make unsafe or unethical decisions, under any situation or circumstance. AI models must specify the scope of proficiencies and the certainty of their safe use across multifarious subgroups according to available risk assessment measures. Finally, detailed instructions on how to use the machine should be provided with fully extensive documentation on the predictive accuracy, the limitations of the model, the types of errors along with their frequency or rates of occurrences, and the severity of the side effects stemming from these errors[65,66].

Physicians and AI will be the two sides of the same coin, inherently. It is crucial to proactively control the adoption of AI as a complementary tool in the healthcare system to augment the intellectual and practical functions of the physician without sacrificing humanism, the indispensable existence of the practitioner's unwavering cognitive reasoning, and the ethics of medicine. New AI and ML techniques have the potential to improve work activity in the healthcare sector. However, they require further refinement before they can be introduced into daily practice. This encompasses technical problems, such as uncertainty quantification, inclusion of more patient-centered outcome measures and important ethical issues notably regarding hidden biases as well as the transparency of data processing and the explainability of results. Thereafter, AI models may become a valuable component of the care team.

Ethical approval

All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1964 and later versions. The research protocol has been notified to the local IRB. Ethical review and approval were waived for this study due to the study is an Editorial.

Consent

All consent obtained.

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Author contributions

V.B.: conceptualization, methodology, data curation, formal analysis, writing – original draft, writing – reviewing and editing. F.M.: investigation, formal analysis, data curation, writing – reviewing and editing. F.P.: data curation, formal analysis, writing – reviewing and editing. C.N.: conceptualization, data curation, formal analysis. M.M.C.: conceptualization, methodology, writing – reviewing and editing. G.B.: conceptualization, methodology, data curation, formal analysis, writing – original draft, writing – reviewing and editing.

Conflicts of interest disclosure

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Data availability statement

The authors confirm that the data supporting the findings of this study are available within the article. All authors have given full approval of the version to be published.

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