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Surgeons' perspectives on artificial intelligence to support clinical decision-making in trauma and emergency contexts: results from an international survey

Lorenzo Cobianchi^{1,2,3*†}, Daniele Piccolo^{1,4†}, Francesca Dal Mas^{5†}, Vanni Agnoletti⁶, Luca Ansaloni^{1,2}, Jeremy Balch⁷, Walter Biffi⁸, Giovanni Butturini⁹, Fausto Catena⁶, Federico Coccolini¹⁰, Stefano Denicolai^{3,11}, Belinda De Simone¹², Isabella Frigerio⁹, Paola Fugazzola^{1,2}, Gianluigi Marseglia^{1,13}, Giuseppe Roberto Marseglia¹⁴, Jacopo Martellucci¹⁵, Mirko Modenese¹⁶, Pietro Previtali^{3,11}, Federico Ruta¹⁷, Alessandro Venturi^{3,18,19}, Haytham M. Kaafarani^{20,21}, Tyler J. Loftus⁷ and Team Dynamics Study Group

Abstract

Background Artificial intelligence (AI) is gaining traction in medicine and surgery. AI-based applications can offer tools to examine high-volume data to inform predictive analytics that supports complex decision-making processes. Time-sensitive trauma and emergency contexts are often challenging. The study aims to investigate trauma and emergency surgeons' knowledge and perception of using AI-based tools in clinical decision-making processes.

Methods An online survey grounded on literature regarding AI-enabled surgical decision-making aids was created by a multidisciplinary committee and endorsed by the World Society of Emergency Surgery (WSES). The survey was advertised to 917 WSES members through the society's website and Twitter profile.

Results 650 surgeons from 71 countries in five continents participated in the survey. Results depict the presence of technology enthusiasts and skeptics and surgeons' preference toward more classical decision-making aids like clinical guidelines, traditional training, and the support of their multidisciplinary colleagues. A lack of knowledge about several AI-related aspects emerges and is associated with mistrust.

Discussion The trauma and emergency surgical community is divided into those who firmly believe in the potential of AI and those who do not understand or trust AI-enabled surgical decision-making aids. Academic societies and surgical training programs should promote a foundational, working knowledge of clinical AI.

Keywords Artificial intelligence, Clinical decision-making, Decision aids, Trauma and emergency surgery, Survey

[†]Lorenzo Cobianchi, Daniele Piccolo, and Francesca Dal Mas share the first authorship

*Correspondence:

Lorenzo Cobianchi

lorenzo.cobianchi@unipv.it

Full list of author information is available at the end of the article



Background

Artificial intelligence (AI) is defined as the development of algorithms that give machines the ability to act with human-like rationality in complex tasks, such as problem-solving and decision-making, and is poised to reshape medicine and surgery broadly [1].

Diagnostic and judgment errors are the second leading cause of preventable harm [2]. Decision-making is one of the most challenging and crucial tasks performed by trauma and emergency surgeons, where time constraints and high cognitive loads from high volumes of information demand reliance on cognitive shortcuts, leading to mistakes and preventable patient harm [3].

In recent years, decision support systems based on AI algorithms are receiving considerable attention in the literature [4–6]. In contrast to human cognitive capacities, AI can be used to examine high-complexity and high-volume data for predictive analytics to augment the precision of complex decision-making processes. Nonetheless, deploying medical AI systems in routine trauma and emergency surgery care presents a critical yet largely unfulfilled opportunity as the medical AI community steers the complex ethical, technical, and human-centered challenges required for safe and adequate translation [7–10]. Experienced surgeons are appropriately cautious of enthusiastic, novel solutions that are unsubstantiated by academic rigor and evidence of performance advantages in clinical settings [8]. Even when AI accurately predicts clinical outcomes hours or days in advance, its application in trauma and emergency surgery will remain marginal until the deployment proves trust in the accuracy and the lack of bias of the model, addresses target risk-sensitive decisions, and integrates with clinical workflows [11, 12].

The recently published artificial intelligence in Emergency and Trauma Surgery (ARIES) survey, endorsed by the World Society of Emergency Surgery (WSES) evaluated the knowledge, attitude, and practices in the application of AI in the emergency setting among international acute care and emergency surgeons. The investigation revealed how the implementation of AI in the emergency and trauma setting is highly anticipated but still in an early phase, with trauma and emergency surgeons enthusiastic about being involved [13].

Starting from these premises and research gaps, this article aims to assess surgeons' understanding and knowledge about the role of new technologies like AI in clinical decision-making by employing an international survey endorsed by the WSES.

Methods

Design and setting

The exploratory study of the international trauma and emergency surgeons' community used a population-based online questionnaire to gather demographic, knowledge, and practice-based information regarding the adoption of new technological tools to support clinical decision-making. The online questionnaire was generated in English through Google Forms [14, 15], and followed the Checklist for Reporting Results of Internet E-Surveys (CHERRIES) [16].

A steering committee within the WSES was appointed, involving a multidisciplinary panel of academics and practitioners in the fields of trauma and emergency surgery, healthcare management and policies, innovation, business and medical ethics, information technology, law, and organization science. No Institutional Review Board (IRB) approval was required. Starting from a review of the literature, a research protocol was conceived and shared by the principal investigators (LC and FDM) with the steering committee. The protocol was peer-reviewed and published [17]. The leading references to create the protocol and the survey structure were gathered from Dal Mas et al. [18], Loftus et al. [19, 20], Cobianchi et al. [21], Venkatesh et al. [22], and Bashshur, Shannon and Sapci [23]. Before the initiative's official launch, the research protocol and the online survey were reviewed by the steering committee and filled in by a sample of surgeons to avoid mistakes.

The poll was made available at the end of November 2021 and was open until the middle of August 2022. All 917 WSES members received an e-mail invitation to participate in the survey. The initiative was also shared on the society's website and Twitter account. Additionally, the members of the Team Dynamics Study Group [14, 15] were also invited via e-mail. Four e-mail reminders were sent. WSES membership was not required to answer the survey. Still, it may be assumed that the vast majority of the participants come from the 917 WSES members to whom the research initiative was publicized, yielding an approximate 70% response rate.

The invitation e-mail included comprehensive details on the initiative's goals and rationale, the anticipated time frame (about 10 min), and the option to join the Team Dynamics Study Group to carry out additional research and disseminate the results. The identities of the participants were kept secret. Additionally, the identity of the investigators and the research protocol were kept private.

Table 1 Descriptive statistics about surgeons and institutions participating in the investigation

Item	Number of responses	% of total responses
Participants	650	100.00%
Males	531	81.69%
Females	118	18.15%
Prefer not to answer	1	0.15%
	Mean	SD
Years of experience	12.32	8.42
Minimum	1	
Maximum	36	
Kind of institution	Number	%
	650	100.00%
Academic	499	76.77%
Non-academic	151	23.23%
Role/position	650	100.00%
Senior Consultant	233	35.85%
Board-certified surgeon	179	27.54%
Resident	124	19.08%
Division chief or head	114	17.54%
Part of an emergency surgery team	650	100.00%
Yes	540	83.08%
No	110	16.92%

Survey

The first group of questions aimed at understanding the participants' features. The questions' structure and list were derived from the previous Team Dynamics investigation [14, 15]. Surgeons were asked to disclose their gender, years of experience in trauma/emergency surgery, type of institution (academic versus non-academic), the country in which they work, role, eventual participation within a trauma team (institutionalized or not, and of which type), the kind of trauma leader, the educational training attended, and the eventual presence of diverse team members.

The second group of questions investigated the decision aids as reported by the surgical literature [18–20], by assessing the surgeons' perception of 11 items using a 5-point Likert scale.

The third group of questions concerned the perceived challenges that surgeons need to face when making clinical decisions, assessing 13 items gathered from Loftus and colleagues [20] using a 5-point Likert scale.

The fourth section of the questionnaire aimed at assessing the surgeons' feelings about AI by asking them if they were familiar with the term AI, their understanding of it through an open question, and the perceived importance of AI in surgery at the present time and in a five-year

horizon. One last question aimed to assess the perceived benefits [21, 22] of the application of AI in surgery.

The survey's questions related to clinical decision-making through new technological aids are reported in Appendix 1.

Statistical analysis

The statistical analysis was conducted using the software R (RStudio 2022.07.0 + 548 "Spotted Wakerobin" Release) [24].

Manual coding was also employed concerning the qualitative questions. Surgeons were required to express their understanding of AI through an open question. Results were manually coded by two researchers (LC and FDM), who rated each statement as concordant, discordant, or inconclusive, following the analysis of Woltz et al. [25] and Cobianchi et al. [14].

Results

Participants

650 surgeons responded to the questionnaire. Located on five continents, participants hailed from 71 different nations. The sample, however, was not evenly dispersed, with the majority of surgeons coming from Europe (477, or 73%), particularly Italy (251, or 39%). 465 responders

(72%) were from the 10 nations with the most participants overall.

118 female surgeons (18%), 531 male surgeons (82%), and one person who would rather remain anonymous made up the sample. Surgeons' years of experience in the field ranged from 1 to 35, with a mean of 12. The majority of participants (499, or 77% of the sample) were from academic institutions, and 540 of them declared to be part of a formally-established emergency surgery team (83%). Although there were a variety of roles indicated, senior consultants made up the bulk of surgeons (233, or 36%). Department heads made up 114 (18%) of the sample.

Table 1 presents descriptive statistics about the individuals and institutions that participated in the study, whereas Table 2 reports some information about the number of respondents according to their locations.

Clinical decision-making facilitators

Surgeons were given a list of 11 items referred to clinical decision-making facilitators to be rated on a 5-point Likert scale according to their perceived importance. Clinicians underlined the importance of training, clinical guidelines, and multidisciplinary committees and meetings, with a mean of over 4 out of 5. Interestingly, the most modern tools (namely, risk stratification by additive scores using static variable thresholds, machine learning and artificial intelligence, regression modeling

Table 3 Decision aids and facilitators

	Item	Mean	SD
1	Training	4.40	0.78
2	Clinical guidelines and cases	4.25	0.82
3	Multidisciplinary committees and meetings	4.19	0.85
4	Time spent to engage patients	4.10	0.89
5	Networking and international experiences	4.10	0.88
6	Non-technical skills	3.98	1.02
7	Mobile electronic medical records and online tools, including telemedicine	3.96	1.02
8	Publications	3.95	0.94
9	Risk stratification by additive scores using static variable thresholds	3.87	0.91
10	Machine Learning and Artificial Intelligence	3.56	1.07
11	Regression modeling and calculations	3.49	1.01

and calculations—with 3.87, 3.56, and 3.49, respectively) received the lowest scores, with machine learning and artificial intelligence recording the highest standard deviation (1.07). The following Table 3 reports the results.

The responses given to the item “Machine Learning and Artificial Intelligence” were analyzed by dividing the sample by institution, position held, and country. Interestingly, the institution (academic or non-academic) and the role did not show any significant difference. Major differences emerged when analyzing countries, with

Table 2 Number of respondents according to their location

Total participants	650	100%
<i>Number of countries</i>	71	
<i>Continents</i>	5	100%
Europe	477	73%
Asia	85	13%
America	62	10%
Africa	22	3%
Oceania	4	1%
Ten most present countries	465	72%
Italy	251	39%
Greece	45	7%
Spain	37	6%
United Kingdom	37	6%
United States	26	4%
Turkey	16	2%
Malaysia	15	2%
France	14	2%
Brazil	13	2%
Ukraine	11	2%

Table 4 Item 10 “Machine Learning and Artificial Intelligence” responses per country

id	Country	# responses	Mean	SD
1	Argentina	6	4.5	0.548
2	Saudi Arabia	7	4.43	1.13
3	Brazil	13	4.38	0.768
4	Malaysia	15	4.13	1.30
5	India	8	4.12	0.835
6	France	15	4.07	0.884
7	United States	24	3.92	1.21
8	Ukraine	11	3.91	0.944
9	Bulgaria	9	3.89	0.928
10	Belarus	6	3.83	0.753
11	Russia	5	3.8	1.64
12	Spain	37	3.68	1.03
13	Netherlands	10	3.6	0.843
14	Germany	7	3.57	0.535
15	Romania	9	3.56	1.13
16	Turkey	16	3.5	0.966
17	Greece	45	3.42	1.14
18	Japan	5	3.4	0.548
19	Portugal	5	3.4	0.548
20	Italy	251	3.38	1.10
21	United Kingdom	37	3.35	1.09
22	Israel	6	3.17	0.408
23	Thailand	6	2.67	0.816
24	Canada	5	2.6	0.548
25	Switzerland	5	2.6	0.894

some of them (like Argentina) showing a high mean (4.5) and a low standard deviation (0.548), and others (like Switzerland) a very low mean (2.6) and a high standard deviation (0.89). Such results are reported in the following Table 4.

Moreover, the same responses were analyzed by considering the institution, position, and country simultaneously. Although numbers become smaller, some interesting findings emerge. For instance, all senior consultants belonging to Malaysian academic institutions firmly believed in AI, with all of them giving a rate of 5/5, compared to division chiefs working in the USA, who scored the item 2.5 with a standard deviation of 1.05. Despite being digital natives, residents do not appear in the top positions. Results are depicted in the following Table 5.

Challenges in clinical decision-making

Surgeons were asked to rate 13 items regarding the challenges that could arise when engaging in clinical decision-making. The items were adapted from Loftus et al. [20].

Results underline a perceived misalignment between the actual clinical scenario and the independent assessment, the lack of complete data availability, the risk of expecting specific outcomes grounded on inaccurate data, the presence of bias derived from the most recent experiences, and the possibility of making mistakes all along the clinical journey. Interestingly, surgeons rated the potential support granted by new technologies like AI as the lowest item (with a mean of 3.10 and the highest standard deviation of 1.14).

Findings are reported in the following Table 6.

Knowledge and understanding of AI

Surgeons were asked if they were familiar with the term AI. 451 out of 650 participants (69% of the sample) declared they were familiar with the term, while 199 (31%) admitted they were not.

The following question required surgeons to write their understanding of AI applied to surgery. Each given statement was rated by the two principal investigators (LC and FDM) as concordant, discordant, or inconclusive.

To be rated as concordant, definitions needed to somehow stress the capability of the machine to mimic human intelligence or, at least, to express the aims and potential of AI applied to surgical practice or its technological functioning. Only 112 surgeons (17% of the sample) provided a statement that fitted the criterion. 178 participants (27% of the sample) gave responses that were incomplete, showing only a partial view of the phenomenon, being so rated as inconclusive. The remaining 360 surgeons (55% of the participants) gave answers that were not fitting the concept of AI, its aims, and its potential. Most of these participants declared they had no idea about what AI could entail in surgical practice.

The following Table 7 reports some examples of answers that were rated as concordant, inconclusive, and discordant [14, 25].

The statements were also analyzed according to different keys, namely, the fact that they recalled the idea of AI supporting clinical decision-making and of learning/training, and the eventual other technologies linked to AI. Most surgeons (409, 63% of the sample) mentioned the impact on clinical decision-making, and 57 (9%)

Table 5 Item 10 “Machine Learning and Artificial Intelligence” responses per institution, position, and country

id	Institution	Position	Country	#	Mean	SD
1	Academic	Senior-consultant	Malaysia	5	5	0
2	Academic	Division-chief	Brazil	7	4.57	0.535
3	Academic	Board-certified-surgeon	United-States	6	4.5	0.837
4	Academic	Senior-consultant	United-States	5	4.2	0.447
5	Academic	Board-certified-surgeon	France	6	4.17	0.753
6	Academic	Board-certified-surgeon	Greece	12	4	1.28
7	Academic	Division-chief	Ukraine	6	4	0.894
8	Academic	Resident	United-Kingdom	6	4	0.894
9	Academic	Senior-consultant	Bulgaria	5	4	1
10	Non-academic	Resident	United-Kingdom	8	3.88	1.13
11	Academic	Division-chief	Turkey	6	3.83	0.983
12	Academic	Resident	Greece	13	3.69	0.947
13	Academic	Senior-consultant	Romania	8	3.62	1.19
14	Academic	Board-certified-surgeon	Italy	45	3.6	1.18
15	Academic	Senior-consultant	Spain	20	3.6	0.995
16	Academic	Board-certified-surgeon	Malaysia	6	3.5	1.05
17	Non-academic	Senior-consultant	Italy	39	3.46	1.14
18	Academic	Board-certified-surgeon	Spain	11	3.46	1.13
19	Non-academic	Division-chief	Italy	14	3.43	0.756
20	Non-academic	Resident	Italy	5	3.4	0.548
21	Academic	Senior-consultant	Italy	46	3.35	1.06
22	Academic	Resident	Italy	56	3.34	1.16
23	Academic	Senior-consultant	Turkey	7	3.29	0.951
24	Non-academic	Senior-consultant	Greece	7	3.29	0.951
25	Academic	Senior-consultant	United-Kingdom	9	3.22	1.09
26	Academic	Division-chief	Israel	5	3.2	0.447
27	Non-academic	Board-certified-surgeon	Italy	29	3.17	1.04
28	Academic	Board-certified-surgeon	United-Kingdom	6	3.17	1.17
29	Academic	Division-chief	Italy	17	3.12	1.27
30	Academic	Senior-consultant	Greece	5	2.8	1.1
31	Academic	Division-chief	United-Kingdom	6	2.67	0.816
32	Non-academic	Board-certified-surgeon	Greece	5	2.6	0.548
33	Academic	Division-chief	United-States	6	2.5	1.05

recalled the potential of AI for surgical training. Among the most cited technologies that may be linked with AI, there are Big Data (mentioned by 130 participants – 20% of the sample) and new technologies in general terms (107, 16%).

Table 8 highlights such results.

The potential of AI today and tomorrow

Surgeons were asked to express their opinion about the importance of AI-based applications to support clinical decision-making at the current time and on a five-year horizon, using a 5-point Likert scale.

Participants rated the importance today with a mean of 3.06 out of 5 and a standard deviation of 1.1. In the future, the sample rated the importance as 3.88 as an average with a standard deviation of 0.97.

The goals of AI

One last question referred to the perceived goals and benefits of AI-based in supporting clinical decision-making. Five items needed to be rated on a 5-point Likert scale.

Interestingly, surgeons rated all five items as equally relevant (ranging from a mean score of 3.51 to 3.78). The

Table 6 Challenges in clinical decision-making

Item	Mean	SD
1 Sometimes the clinical scenario presented is different than the surgeon would have perceived during an independent assessment	3.61	0.95
2 Data are often incomplete	3.54	1.00
3 Patients are often informed of expected outcomes using data from aggregate patient populations without adjusting for their personalized risk profile	3.51	1.06
4 Recent experiences with a certain patient population or operation often affect disproportionately surgical decision-making than remote ones	3.50	0.98
5 Errors and mistakes are likely all along the way	3.49	1.09
6 Decisions must often be made before all relevant data can be retrieved	3.44	1.10
7 Potential outcomes are often predicted using personal beliefs rather than evidence-based guidelines	3.38	1.11
8 In-house calls happen often	3.35	1.00
9 It is often too complicated to form a complete list of all likely diagnoses, all life-threatening diagnoses, and all unlikely diagnoses that may be considered if the initial workup excludes other causes	3.34	1.04
10 A surgeon tends toward action when inaction may be preferable	3.28	1.07
11 The surgeon often falsely perceives that weaknesses and failures disproportionately affect their peers	3.17	1.01
12 It is often too complicated to recognize the strengths and limitations of available tests	3.12	1.02
13 Digital technologies (e.g., artificial intelligence) support how I take clinical decisions	3.10	1.14

item with the highest score sees AI as a support tool to validate decisions that clinicians would make anyway.

The following Table 9 reports the results.

Discussion

The results of our survey are in line with previous studies [13], with trauma and emergency surgeons showing interest in AI but still having several doubts and concerns about its actual application and potential as a decision-making aid.

When enquired about the most effective tools to support clinical decision-making, surgeons declare to rely more on training, clinical guidelines, and the support of their multidisciplinary staff and colleagues. Interestingly, these three items represent central and “classical” elements in the trauma and emergency surgery context [14] and in the action of the leading scientific societies like the WSES, which promotes training modules for both physicians and nurses [26], clinical guidelines covering several aspects of the clinical profession [27], and studies on multidisciplinary team dynamics [14, 15]. AI and Machine Learning tools got one of the lowest rates (3.56), with the highest standard deviation (1.07). The broad standard deviation interval may represent a gap in the surgical community, with some surgeons firmly believing in the potential of such new technologies and others still having severe concerns about their practical application.

Interestingly, while no significant differences emerge when considering the institution and the position held,

geographical differences occur in the sample, with some countries giving higher scores than others. It would be interesting to investigate further while such differences emerge, for instance, in terms of cultural mindset, training opportunities, availability of technology or tech partners, and presence of technological surgical leaders or ambassadors. Moreover, when analyzing the sample under different lenses simultaneously (institution, role, and country), residents do not appear to be technology enthusiasts and believers, despite their younger age and the definition of digital natives.

When considering the decision-making process dynamics, trauma and emergency surgeons underline the need for sound decision aids. Indeed, the most rated elements refer to the potential gap between reality and the surgeon’s initial assessment and the lack of accurate data. Even in this case, most respondents did not believe that AI offers valuable support for decision-making. Like in the case of decision aids, the contribution of AI to decision-making got the highest standard deviation, depicting the two extreme views, with enthusiastic adopters in contrast with skeptics.

Regarding the knowledge about AI, while most surgeons declare to be familiar with the concept of AI, many exhibited only a partial understanding of AI. Interestingly, many surgeons recall big data technology, and some associate AI primarily with robotics. While robotic surgery may represent one promising application of AI in surgical science [13, 28, 29], AI in its current state offers sound decision-making support, like

Table 7 Examples and ways of rating the given answers to the question: What is your understanding of AI applied to surgery?

Rated as	Given answer	Reason for rating
Concordant	<p>"Capability of a machine to imitate intelligent human behavior."</p> <p>"It is capability of a computer system to mimic human cognitive functions."</p> <p>"A set of computer systems aiming at performing tasks normally based on human intelligence, starting from repetitive task and upscaling upon results."</p> <p>"Artificial intelligence is a technology which enables a machine to simulate human behavior. Machine learning is a subset of AI which allows a machine to automatically learn from past data without programming explicitly."</p> <p>"Artificial intelligence is the ability of a computer system to mimic human cognitive functions. Through AI, a computer system may simulate also the reasoning that people use to acquire new information and make decisions."</p> <p>"The ability of machines to learn complex data and then generate predictions can assist clinical decisions and which can be used to improve clinical care in surgery."</p> <p>"[AI] help[s] in the surgical daily practice obtained thanks to shared experience, obtained from several colleagues, throughout the collection of big data analyzed and optimized by means of computational analysis"</p> <p>"AI/ML are not yet applicable in an extensive way to surgery. However, some relevant applications, particularly during the diagnostic phase (especially radiology), can influence surgical indication. After surgery, some examples of AI/ML algorithms are used in pathology to define the diagnosis better, thus the patient's prognosis."</p> <p>"[AI] works by combining large amounts of data with fast, iterative processing and intelligent algorithms, allowing software to automatically learn from data patterns or characteristics."</p> <p>"Application of big data."</p> <p>"Simulation."</p> <p>"Telemedicine; robotic training."</p> <p>"Use of artificial intelligence for learning."</p> <p>"Technology using to facilitate decisions."</p> <p>"Useful for risk stratification and some decision-making."</p> <p>"It can help in making decisions and developing new techniques."</p> <p>"A predictive model"</p>	<p>The statement recalls the ability of AI to mimic human behavior</p>
Inconclusive	<p>"I don't have a deep understanding of how these work, although I have seen several publications on this lately."</p> <p>"I don't know."</p> <p>"None."</p> <p>"Nothing."</p> <p>"I don't know AI applied to surgery."</p> <p>"Robotic surgery."</p> <p>"Robots."</p> <p>"AI applied to surgical field."</p>	<p>The statement stresses the learning aspect and the capability to handle complex data to support decision-making</p> <p>The statement shows a good understanding of the goals and potential of AI applied to surgery</p> <p>The statement shows a good understanding of how the technology works</p> <p>Although big data may be linked with the functioning of AI, the statement is incomplete</p> <p>Although simulations may be linked with the functioning of AI, the statement is incomplete</p> <p>Although telemedicine/e-health and robotic surgery may be somehow linked with the functioning of AI, the statement is incomplete</p> <p>The statement recalls only one scope, which is, by the way, not well identified</p>
Discordant	<p>"I don't know AI applied to surgery."</p> <p>"Robotic surgery."</p> <p>"Robots."</p> <p>"AI applied to surgical field."</p>	<p>In the statements, participants admit they have poor or no knowledge about AI applied to surgery</p> <p>Although the literature is starting to discuss AI-empowered surgical robots, the actual robotic surgical systems do not work with AI</p> <p>Redundant/repetition</p>

Table 8 Understanding of AI applied to surgery – Main results

Aims	#	%
Mentions the potential in supporting clinical decision-making	409	63
Mentions the potential in supporting learning/training activities	57	9
Technologies linked with AI		
Big data	130	20
New technologies in general	107	16
Robotics	22	3
Simulations	16	2
Virtual/augmented realities	8	1
Telemedicine	1	0
No other technologies mentioned	366	56
Total	650	

Table 9 Goals and benefits of AI applied to surgery

Item	Mean	SD
1 It helps in evaluating/validating decisions I would take	3.78	1.01
2 It supports in taking complex clinical decisions;	3.73	1.10
3 It helps in scouting and reviewing publications;	3.70	1.03
4 It reduces the span of options;	3.53	1.01
5 It supports taking decisions regarding simple problems, so I can focus on high-value activities	3.51	1.10

in the case of the POTTER algorithm as an emergency surgery risk calculator [5, 6].

The current general skepticism of trauma and emergency surgeons about AI is also confirmed by the given rate on the relevance of AI-based tools for decision-making as they appear today, with a mean of 3.06. One more time, a high standard deviation interval depicts divergent opinions and beliefs in the surgical community. Still, the future looks brighter, with a higher perceived relevance on a five-year horizon.

The same picture and the divergent trust in using AI-based decision tools emerge in the question about the goals and benefits. Interestingly, the degree of technology acceptance appears generally low, with surgeons being rather skeptical when it comes to AI ensuring better support and outcomes than traditional tools. Such a low degree of acceptance opens up new research avenues to investigate the main concerns in the practical adoption of AI or the ethical bias connected to it. In such a perspective, one primary concern may reside in the lack of technical knowledge regarding AI, which emerges from several questions,

especially that on the understanding of AI. Moreover, when enquired about legal responsibility (a topic to which medical doctors are particularly sensitive), surgeons modestly rate the need to share their legal responsibility with either the manufacturer, those in charge of maintenance, or the data manager, and so the need to rethink the informed written consent when new technologies are involved.

Limitations

Although our survey got a reasonably high response rate and 650 participants (approximately 70%), the sample is not equally distributed geographically. Indeed, most participants work in Europe and, more specifically, in Italy. The specific situation of the Italian and European contexts, including the actual access to AI-based technology and the medical education related to it, may have biased some of our results. Our limitations, along with the international community's perceived interest in AI [13], may stimulate new in-depth studies and investigations.

Conclusion

In concluding our work, we return to the premises and research gaps that inspired it. AI-based applications are gaining traction in surgery as decision-making aids, and the surgical community is showing interest in them. Trauma and emergency contexts are often challenging, and surgeons perceive the need for sound decision-making tools.

Our results underline how the emergency surgical community seems to include surgeons who strongly believe in the potential contribution of AI technology and who may act as enthusiastic early adopters [19] and those who are reluctant, feeling more comfortable relying upon more classical aids like guidelines, traditional training, and multidisciplinary groups' support. Some countries seem to have greater comprehension and trust of AI-based tools. Younger surgeons, who some presume to be keener on using new technologies, do not appear to have greater trust or understanding of AI compared with mid-career and senior surgeons.

Given the potential of AI in clinical practice [7, 20, 30] and the speed of development, the role of scientific societies like the WSES and surgical training programs are crucial to expanding knowledge regarding AI-enabled decision aids, disseminate new approaches, and encompass them in training modules and clinical guidelines, to bridge the gaps between technology enthusiasts and those who misunderstand and mistrust AI. In addition, AI-enabled decision aids in surgery should seek to gain the trust of surgeons by establishing transparency and by demonstrating performance advantages that improve patient care.

Appendix 1

1. On a scale from 1 to 5, where 1 = not suitable and 5 = very suitable, which are the tools that, in your opinion, may facilitate clinical decision making?

Likert scale 1 to 5

1. Mobile electronic medical records and online tools, including telemedicine
2. Training
3. Networking and international experiences
4. Multidisciplinary committees and meetings
5. Publications
6. Clinical guidelines and cases
7. Time spent to engage patients
8. Non-technical skills
9. Risk stratification by additive scores using static variable thresholds.
10. Regression modelling and calculations
11. Machine learning and Artificial intelligence

2. Think of how you take clinical decisions. On a scale from 1 to 5, where 1 = strongly disagree and 5 = strongly agree, how would you rate the following statements?

Likert scale 1 to 5

1. It is often too complicated to form a complete list of all likely diagnoses, all life-threatening diagnoses, and all unlikely diagnoses that may be considered if the initial workup excludes other causes.
2. It is often too complicated to recognize the strengths and limitations of available tests.
3. Errors and mistakes are likely all along the way.
4. Data are often incomplete.
5. Decisions must often be made before all relevant data can be retrieved
6. In-house calls happen often
7. Sometimes the clinical scenario presented is different than the surgeon would have perceived during an independent assessment
8. The surgeon often falsely perceives that weaknesses and failures disproportionately affect their peers
9. A surgeon tends toward action when inaction may be preferable
10. Patients are often informed of expected outcomes using data from aggregate patient populations without adjusting for their personalized risk profile
11. Recent experiences with a certain patient population or operation often affect disproportionately surgical decision-making than remote ones.
12. Potential outcomes are often predicted using personal beliefs rather than evidence-based guidelines
13. Digital technologies (e.g. artificial intelligence) support how I take clinical decisions

3. Are you familiar with the terms Artificial Intelligence/Machine Learning?

Yes/No

AI and decision making in trauma and emergency contexts

1. Yes
2. No

4 What is your understanding of Artificial Intelligence/Machine Learning applied to surgery?

open question

5. On a scale from 1 to 5, where 1 = not relevant and 5 = very relevant, how relevant do you think that Machine learning and Artificial intelligence-based tools are today for clinical decision making?

Likert scale 1 to 5

6. On a scale from 1 to 5, where 1 = not relevant and 5 = very relevant, how relevant do you think that Machine learning and Artificial intelligence-based tools will be for clinical decision making in a five-year horizon?

Likert scale 1 to 5

7. On a scale from 1 to 5, where 1 = strongly disagree and 5 = strongly agree, how would you rate the following statements concerning the goal and benefits of Machine learning and Artificial intelligence-based in supporting clinical decision making?

Likert scale 1 to 5

1. - it helps in scouting and reviewing publications;
2. - it reduces the span of options;
3. - it supports taking decisions regarding simple problems, so I can focus on high-value activities;
4. - it supports in taking complex clinical decisions;
5. - it helps in evaluating/validating decisions I would take.

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Abbreviations

AI	Artificial intelligence
WSES	World society of emergency surgery
CHERRIES	Checklist for reporting results of internet e-surveys
IRB	Institutional review board
SD	Standard deviation

Acknowledgements

Please see the list of the Team Dynamics Study Group members.

Kenneth Lyle Abbott¹, Abubaker Abdelmalik², Nebyou Seyoum Abebe³, Fikri Abu-Zidan⁴, Yousif Abdallah Yousif Adam⁵, Harissou Adamou⁶, Dmitry Mikhailovich Adamovich⁷, Ferdinando Agresta⁸, antonino Agrusa⁹, Emrah Akin¹⁰, Mario Alessiani¹¹, Henrique Alexandrino¹², Syed Muhammad Ali¹³, Vasilescu Alin Mihai¹⁴, Pedro Miguel Almeida¹⁵, Mohammed Mohammed Al-Shehari¹⁶, Michele Altomare¹⁷, Francesco Amico¹⁸, Michele Ammendola¹⁹, Jacopo Andreuccetti²⁰, Elissavet Anestiadou²¹, Peter Angelos²², Alfredo Annicchiarico²³, Amedeo Antonelli²⁴, Daniel Aparicio-Sanchez²⁵, antonella Ardito²⁶, Giulio Argenio²⁷, Catherine Claude Arvieux²⁸, Ingolf Harald Askevold²⁹, Boyko Tchavdarov Atanasov³⁰, Goran Augustin³¹, Selmy Sabry Awad³², Giulia Bacchiocchi³³, Carlo Bagnoli³⁴, Hany Bahouth³⁵, Efstratia Baili³⁶, Lovenish Bains³⁷, Gian Luca Baiocchi³⁸, Miklosh Bala³⁹, Carmen Balagué⁴⁰, Dimitrios Balalis⁴¹, Edoardo Baldini⁴², oussama Baraket⁴³, Suman Baral⁴⁴, Mirko Barone⁴⁵, Alberto González Barranquero⁴⁶, Jorge Arturo Barreras⁴⁷, Gary Alan Bass⁴⁸, Zulfu Bayhan⁴⁹, Giovanni Bellanova⁵⁰, Offir Ben-Ishay⁵¹, Fabrizio Bert⁵², Valentina Bianchi⁵³, Helena Biancuzzi⁵⁴, Chiara Bidoli⁵⁵, Raluca Bievel Radulescu⁵⁶, Mark Brian Bignell⁵⁷, Alan Biloslavo⁵⁸, Roberto Bini⁵⁹, Daniele Bissacco⁶⁰, Paoll Boati⁶¹, Guillaume Boddaert⁶², Branko Bogdanic⁶³, Cristina Bombardini⁶⁴, Luigi Bonavina⁶⁵, Luca Bonomo⁶⁶, Andrea Bottari⁶⁷, Konstantinos Bouliaris⁶⁸, Gioia Brachini⁶⁹, Antonio Brillantino⁷⁰, Giuseppe Brisinda⁷¹, Maloni Mamada Bulanauca⁷², Luis Antonio Buonomo⁷³, Jakob Burcharth⁷⁴, Salvatore Buscemi⁷⁵, Francesca Calabretto⁷⁶, Giacomo Calini⁷⁷, Valentin Calu⁷⁸, Fabio Cesare Campanile⁷⁹, Riccardo Campo Dall'Orto⁸⁰, Andrea Campos-Serra⁸¹, Stefano Camprostrini⁸², Recayi Capoglu⁸³, Joao Miguel Carvas⁸⁴, Marco Casella⁸⁵, Gianmaria Casoni Pattacini⁸⁶, Valerio Celentano⁸⁷, Danilo Corrado Centonze⁸⁸, Marco Ceresoli⁸⁹, Dimitrios Chatzipetris⁹⁰, Antonella Chessa⁹¹,

Maria Michela Chiarello⁹², Mircea Chirica⁹³, Serge Chooklin⁹⁴, Christos Chouliaras⁹⁵, Sharfuddin Chowdhury⁹⁶, Pasquale Cianci⁹⁷, Nicola Cillara⁹⁸, Stefania Cimbanassi⁹⁹, Stefano Piero Bernardo Cioffi¹⁰⁰, Elif Colak¹⁰¹, Enrique Colás Ruiz¹⁰², Luigi Conti¹⁰³, Alessandro Coppola¹⁰⁴, Tiago Correia De Sa¹⁰⁵, Sílvia Dantas Costa¹⁰⁶, Valerio Cozza¹⁰⁷, Giuseppe Curro¹⁰⁸, Kirsten Felicia Ann-Sophie Aimee Dabekaussen¹⁰⁹, Fabrizio D'acapo¹¹⁰, Dimitrios Damaskos¹¹¹, Giancarlo D'Ambrosio¹¹², Koray Das¹¹³, Richard Justin Davies¹¹⁴, Andrew Charles De Beaux¹¹⁵, Sara Patricia De Lebrusant Fernandez¹¹⁶, Alessandro De Luca¹¹⁷, Francesca De Stefano¹¹⁸, Luca Degrate¹¹⁹, Zaza Demetrashvili¹²⁰, Andreas Kyriacou Demetriades¹²¹, Dzemail Smail Detanac¹²², Agnese Dezi¹²³, Giuseppe Di Buono¹²⁴, Isidoro Di Carlo¹²⁵, Pierpaolo Di Lascio¹²⁶, Marcello Di Martino¹²⁷, Salomone Di Saverio¹²⁸, Bogdan Diaconescu¹²⁹, Jose J. Diaz¹³⁰, Rigers Dibra¹³¹, Evgeni Nikolaev Dimitrov¹³², Vincenza Paola Dinuzzi¹³³, Sandra Dios-Barbeito¹³⁴, Jehangir Farman Ali Diyani¹³⁵, Agron Dogjani¹³⁶, Maurizio Domanin¹³⁷, Mario D'Oria¹³⁸, Virginia Duran Munoz-Cruzado¹³⁹, Barbora East¹⁴⁰, Mikael Ekelund¹⁴¹, Gerald Takem Ekwen¹⁴², Adel Hamed Elbaih¹⁴³, Muhammed Elhadi¹⁴⁴, Natalie Enninghorst¹⁴⁵, Mairam Ernisova¹⁴⁶, Juan Pablo Escalera-Antezana¹⁴⁷, Sofia Esposito¹⁴⁸, Giuseppe Esposito¹⁴⁹, Mercedes Estaire¹⁵⁰, Camilla Nikita Farè¹⁵¹, Roser Farre¹⁵², Francesco Favi¹⁵³, Luca Ferrario¹⁵⁴, Antonjaco Ferrario di Tor Vajana¹⁵⁵, Claudia Filisetti¹⁵⁶, Francesco Fleres¹⁵⁷, Vinicius Cordeiro Fonseca¹⁵⁸, Alexander Forero-Torres¹⁵⁹, Francesco Forfori¹⁶⁰, Laura Fortuna¹⁶¹, Evangelos Fradelos¹⁶², Gustavo P. Fraga¹⁶³, Pietro Fransvea¹⁶⁴, Simone Frassinì¹⁶⁵, Giuseppe Frazzetta¹⁶⁶, Erica Pizzocaro¹⁶⁷, Maximos Frountzas¹⁶⁸, Mahir Gachabayov¹⁶⁹, Rita Galeiras¹⁷⁰, Alain A. Garcia Vazquez¹⁷¹, Simone Gargarella¹⁷², Ibrahim Umar Garzali¹⁷³, Wajih Mommtaz Ghannam¹⁷⁴, Faiz Najmuddin Ghazi¹⁷⁵, Lawrence Marshall Gillman¹⁷⁶, Rossella Gioco¹⁷⁷, Alessio Giordano¹⁷⁸, Luca Giordano¹⁷⁹, Carlo Giove¹⁸⁰, Giorgio Giraudo¹⁸¹, Mario Giuffrida¹⁸², Michela Giulii Capponi¹⁸³, Emanuel Gois Jr.¹⁸⁴, Carlos Augusto Gomes¹⁸⁵, Felipe Couto Gomes¹⁸⁶, Ricardo Alessandro Teixeira Gonsaga¹⁸⁷, Emre Gonullu¹⁸⁸, Jacques Goosen¹⁸⁹, Tatjana Goranovic¹⁹⁰, Raquel Gracia-Roman¹⁹¹, Giorgio Maria Paolo Graziano¹⁹², Ewen Alexander Griffiths¹⁹³, Tommaso Guagni¹⁹⁴, Dimitar Bozhidarov Hadzhiev¹⁹⁵, Muad Gamil Haidar¹⁹⁶, Hytham K. S. Hamid¹⁹⁷, Timothy Craig Hardcastle¹⁹⁸, Firdaus Hayati¹⁹⁹, Andrew James Healey²⁰⁰, Andreas Hecker²⁰¹, Matthias Hecker²⁰², Edgar Fernando Hernandez Garcia²⁰³,

Adrien Montcho Hodonou²⁰⁴, Eduardo CancioHuaman²⁰⁵, Martin Huerta²⁰⁶, Aini Fabriza Ibrahim²⁰⁷, Basil Mohamed Salabeldin Ibrahim²⁰⁸, Giuseppe Ietto²⁰⁹, Marco Inama²¹⁰, Orestis Ioannidis²¹¹, Arda Isik²¹², Nizar Ismail²¹³, Azzain Mahadi Hamid Ismail²¹⁴, Ruhu Fadzlyana Jailani²¹⁵, Ji Young Jang²¹⁶, Christos Kalfountzos²¹⁷, Sujala Niatarika Rajsain Kalipershad²¹⁸, Emmanouil Kaouras²¹⁹, Lewis Jay Kaplan²²⁰, Yasin Kara²²¹, Evika Karamagioli²²², Aleksandar Karamarkovic²²³, Ioannis Katsaros²²⁴, Alfie J. Kavalakat²²⁵, Aristotelis Kechagias²²⁶, Jakob Kenig²²⁷, Boris Juli Kessel²²⁸, Jim S. Khan²²⁹, Vladimir Khokha²³⁰, Jae Il Kim²³¹, Andrew Wallace Kirkpatrick²³², Roberto Klappenbach²³³, Yoram Kluger²³⁴, Yoshiro Kobe²³⁵, Efstratios Kofopoulos Lymperis²³⁷, Kenneth Yuh Yen Kok²³⁸, Victor Kong²³⁹, Dimitris P. Korkolis²⁴⁰, Georgios Koukoulis²⁴¹, Bojan Kovacevic²⁴², Vitor Favali Kruger²⁴³, Igor A. Kryvoruchko²⁴⁴, Hayato Kurihara²⁴⁵, Akira Kuriyama²⁴⁶, Aitor Landaluze-Olavarria²⁴⁷, Pierfrancesco Lapolla²⁴⁸, Ari Leppänen²⁴⁹, Leo Licari²⁵⁰, Giorgio Lisi²⁵¹, Andrey Litvin²⁵², Aintzane Lizarazu²⁵³, Heura Llaquet Bayo²⁵⁴, Varut Lohsirawat²⁵⁵, Claudia Cristina Lopes Moreira²⁵⁶, Eftychios Lostoridis²⁵⁷, Agustán Tovar Luna²⁵⁸, Davide Luppi²⁵⁹, Gustavo Miguel Machain V.²⁶⁰, Marc Maegele²⁶¹, Daniele Maggiore²⁶², Stefano Magnone²⁶³, Ronald V. Maier²⁶⁴, Piotr Major²⁶⁶, Mallikarjuna Manangi²⁶⁷, Andrea Manetti²⁶⁸, Baris Mantoglu²⁶⁹, Chiara Marafante²⁷⁰, Federico Mariani²⁷¹, Athanasios Marinis²⁷², Evandro Antonio Sbalcheiro Mariot²⁷³, Gennaro Martinez²⁷⁵, Alex Martinez Perez²⁷⁶, Costanza Martino²⁷⁸, Pietro Mascagni²⁷⁹, Damien Massalou²⁸⁰, Maurizio Massaro²⁸¹, Belen Matías-García²⁸², Gennaro Mazzarella²⁸³, Giorgio Mazarolo²⁸⁴, Renato Bessa Melo²⁸⁵, Fernando Mendoza-Moreno²⁸⁶, Serhat Meric²⁸⁷, Jeremy Meyer²⁸⁸, Luca Miceli²⁸⁹, Nikolaos V. Michalopoulos²⁹⁰, Flavio Milana²⁹¹, Andrea Mingoli²⁹², Tushar S. Mishra²⁹³, Muyed Mohamed²⁹⁴, Musab Isam Eldin Abbas Mohamed²⁹⁵, Ali Yasen Mohamedahmed²⁹⁶, Mohammed Jibreel Suliman Mohammed²⁹⁷, Rajashekar Mohan²⁹⁸, Ernest E. Moore²⁹⁹, Dieter Morales-García³⁰⁰, MÅyns Muhrbeck³⁰¹, Francesk Mulita³⁰², Sami Mohamed Siddig Mustafa³⁰³, Edoardo Maria Muttillio³⁰⁴, Mukhammad David Naimzada³⁰⁵, Pradeep H. Navsaria³⁰⁶, Ionut Negoici³⁰⁷, Luca Nespoli³⁰⁸, Christine Nguyen³⁰⁹, Melkamu Kibret Nidaw³¹⁰, Giuseppe Nigri³¹¹, Ioannis Nikolopoulos³¹², Donal Brendan O'Connor³¹³, Habeeb Damilola Ogundipe³¹⁴, Cristina Oliveri³¹⁵, Stefano Olmi³¹⁶, Ernest Cun Wang Ong³¹⁷, Luca Orecchia³¹⁸, Aleksei V. Osipov³¹⁹, Muhammad Faied Othman³²⁰, Marco Pace³²¹, Mario Pacilli³²², Leonardo Pagani³²³, Giuseppe Palomba³²⁴, Desire' Pantalone³²⁵, Arpad Panyko³²⁶, Cirol Paolillo³²⁷, Mario Virgilio Papa³²⁸, Dimitrios Papaconstantinou³²⁹, Maria Papadoliopoulou³³⁰, Aristeidis Papadopoulos³³¹, Davide Papis³³², Nikolaos Pararas³³³, Jose Gustavo Parreira³³⁴, Neil Geordie Pary³³⁵, Francesco Pata³³⁶, Tapan Patel³³⁷, Simon Paterson-Brown³³⁸, Giovanna Pavone³³⁹, Francesca Pecchini³⁴⁰, Veronica Pegoraro³⁴¹, Gianluca Pellino³⁴², Maria Pelloni³⁴³, Andrea Peloso³⁴⁴, Eduardo Perea Del Pozo³⁴⁵, Rita Goncalves Pereira³⁴⁶, Bruno Monteiro Pereira³⁴⁷, Aintzane Lizarazu Perez³⁴⁸, Silvia Pérez³⁴⁹, Teresa Perra³⁵⁰, Gennaro Perrone³⁵¹, Antonio Pesce³⁵², Lorenzo Petagna³⁵³, Giovanni Petracca³⁵⁴, Vorapong Phupong³⁵⁵, Biagio Picardi³⁵⁶, Arcangelo Picciariello³⁵⁷, Micaela Piccoli³⁵⁸, Edoardo Picetti³⁶⁰, Emmanouil Pikoulis³⁶¹, Tadeja Pintar³⁶², Giovanni Pirozzolo³⁶³, Francesco Piscione³⁶⁴, Mauro Podda³⁶⁵, Alberto Porcu³⁶⁶, Francesca Privitera³⁶⁷, Clelia Punzo³⁶⁸, Silvia Quaresima³⁶⁹, Martha Alexa Quodettis³⁷⁰, Niels Qvist³⁷¹, Razrim Rahim³⁷², Filipe Ramalho de Almeida³⁷³, Rosnelifaizur Bin Ramely³⁷⁴, Huseyin Kemal Rasa³⁷⁵, Martin Reichert³⁷⁶, Alexander Reinisch-Liese³⁷⁷, Angela Renne³⁷⁸, Camilla Riccetti³⁷⁹, Maria Rita Rodriguez-Luna³⁸⁰, Daniel Roizblatt³⁸¹, Andrea Romanzi³⁸², Luigi Romeo³⁸³, Francesco Pietro Maria Roscio³⁸⁴, Ramey Bin Rosnelifaizur³⁸⁵, Stefano Rossi³⁸⁶, Andres M Rubiano³⁸⁷, Elena Ruiz-Ucar³⁸⁸, Boris Evgeniev Sakakushev³⁸⁹, Juan Carlos Salamea³⁹⁰, Ibrahimia Sall³⁹¹, Lasitha Bhagya Samarakoon³⁹², Fabrizio Sammartano³⁹³, Alejandro Sanchez Arteaga³⁹⁴, Sergi Sanchez-Cordero³⁹⁵, Domenico Pietro Maria Santoanastasio³⁹⁶, Massimo Sartelli³⁹⁷, Diego Sasia³⁹⁸, Norio Sato³⁹⁹, Artem Savchuk⁴⁰⁰, Robert Grant Sawyer⁴⁰¹, Giacomo Scalioli⁴⁰², Dimitrios Schizas⁴⁰³, Simone Sebastiani⁴⁰⁴, Barbara Seeliger⁴⁰⁵, Helmut Alfredo Segovia Lohse⁴⁰⁶, Charalampos Seretis⁴⁰⁷, Giacomo Sermonesi⁴⁰⁸, Mario Serradilla-Martin⁴⁰⁹, Vishal G. Shelat⁴¹⁰, Sergei Shlyapnikov⁴¹¹, Theodoros Sidiropoulos⁴¹², Romeo Lages Simoes⁴¹³, Leandro Siragusa⁴¹⁴, Boonying Siribumrungwong⁴¹⁵, Mihail Slavchev⁴¹⁶, Leonardo Solaini⁴¹⁷, gabriele soldini⁴¹⁸, Andrey Sopuev⁴¹⁹, Kjetil Soreide⁴²⁰, Apostolos Solvatzidis⁴²¹, Phillip Frank Stahel⁴²², Matt Strickland⁴²³, Mohamed Arif Hameed Sultan⁴²⁴, Ruslan Sydoruchuk⁴²⁵, Laraya Sydoruchuk⁴²⁶, Syed Muhammad Ali Muhammad Syed⁴²⁷, Luis Tallon-Aguilar⁴²⁸, Andrea Marco Tamburini⁴²⁹, Nicolò Tamini⁴³⁰, Edward C. T. H. Tan⁴³¹, Jih Huei Tan⁴³², Antonio Tarasconi⁴³³, Nicola Tartaglia⁴³⁴, Giuseppe Tartaglia⁴³⁵, Dario Tartaglia⁴³⁶, John Vincent Taylor⁴³⁷, Giovanni Domenico Tebala⁴³⁸, Ricardo Alessandro Teixeira Gonsaga⁴³⁹, Michel Teuben⁴⁴⁰, Alexis Theodorou⁴⁴¹, Matti

Tolonen⁴⁴², Giovanni Tomasicchio⁴⁴³, Adriana Toro⁴⁴⁴, Beatrice Torre⁴⁴⁵, Tania Triantafyllou⁴⁴⁶, Giuseppe Trigiane Trigiane⁴⁴⁷, Marzia Tripepi⁴⁴⁸, Julio Trostchansky⁴⁴⁹, Konstantinos Tsekouras⁴⁵⁰, Victor Turrado-Rodriguez⁴⁵¹, Roberta Tutino⁴⁵², Matteo Uccelli⁴⁵³, Petar Angelov Uchikov⁴⁵⁴, Bakarne Ugarte-Sierra⁴⁵⁵, Mika Tapani Ukkonen⁴⁵⁶, Michail Vilas⁴⁵⁷, Panteleimon G. Vassiliu⁴⁵⁸, Alain Garcia Vazquez⁴⁵⁹, Rita Galeiras Vazquez⁴⁶⁰, George Velmahos⁴⁶¹, Juan Ezequiel Verde⁴⁶², Juan Manuel Verde⁴⁶³, Massimiliano Veroux⁴⁶⁴, Jacopo Viganò⁴⁶⁵, RAMON VILALLONGA⁴⁶⁶, Diego Visconti⁴⁶⁷, Alessandro Vittori⁴⁶⁸, Maciej Waledziak⁴⁶⁹, Tongporn Wannatoop⁴⁷⁰, Lukas Werner Widmer⁴⁷¹, Michael Samuel James Wilson⁴⁷², Sarah Woltz⁴⁷³, Ting Hway Wong⁴⁷⁴, Sofia Xenaki⁴⁷⁵, Byungchul Yu⁴⁷⁶, Steven Yule⁴⁷⁷, Sanoop Koshy Zachariah⁴⁷⁸, Georgios Zacharis⁴⁷⁹, Claudia Zagh⁴⁸⁰, Andee Dzulkaena Zakaria⁴⁸¹, Diego A. Zambrano⁴⁸², Nikolaos Zampitis⁴⁸³, Biagio Zampogna⁴⁸⁴, Simone Zanghi⁴⁸⁵, Maristella Zantedeschi⁴⁸⁶, Konstantinos Zapsalis⁴⁸⁷, Fabio Zattoni⁴⁸⁸, Monica Zese⁴⁸⁹.

Affiliations: ¹Department of Surgery, University of Florida, Gainesville, USA, ²General Surgery Dept., Misrata Medical Center, Misrata, Libya, ³Department of surgery college of health sciences, Addis Abeba University, Addis Abeba, Ethiopia, ⁴Research Office, College of Medicine and Health Sciences, United Arab Emirates University, Al-Ain, United Arab Emirates, ⁵University Hospital in Waterford, Tullamore, Ireland, ⁶Department of surgery, Faculté des Sciences de la Santé, Zinder, Zinder, Niger, ⁷Department of Surgical Diseases II, Senior Lecturer at Gomel State Medical University, Gomel, Belarus, ⁸Dept. of General Surgery, AUSL52 Trevigiana del Veneto, Vittorio Veneto (TV), Italy, ⁹Department of Surgical, Oncological and Oral Sciences—University of Palermo, Palermo, Italy, ¹⁰Sakarya University Faculty of Medicine, Sakarya, Turkey, ¹¹Department of Clinical Surgical Diagnostic and Pediatric Sciences, University of Pavia—Department of Surgery, ASST Pavia, Pavia, Italy, ¹²Faculty of Medicina, University of Coimbra, Coimbra, Portugal, ¹³Department of Acute Care Surgery, Hamad Medical Corporation, Doha, Qatar, ¹⁴Grigore T Popa University of Medicine and Pharmacy, Iasi Romania, First Surgical Clinic, St Spiridon University Hospital, Iasi, Romania, ¹⁵Centro Hospitalar e Universitario do Algarve—Hospital de Portimão, Portimão, Portugal, ¹⁶Sana'a University—College of medicine, Sana'a, Yemen, ¹⁷Sapienza University of Rome, Rome, Italy, ¹⁸Dept. of Trauma at John Hunter Hospital, School of Medicine and Public Health at University of Newcastle, Newcastle NSW, Australia, ¹⁹Health of Science Department, "Magna Graecia" University Medical School, Digestive Surgery Unit, "Mater Domini" Hospital, Catanzaro, Italy, ²⁰General Surgery 2, ASST Spedali Civili di Brescia, Brescia, Italy, ²¹4th Department of Surgery, Aristotle University of Thessaloniki, Thessaloniki, Greece, ²²Department of Surgery and MacLean Center for Clinical Medical Ethics, The University of Chicago, Chicago, IL, USA, ²³Università di Parma, Italy, ²⁴Università degli studi di Roma Tor Vergata, Rome, Italy, ²⁵Emergency Surgery Unit (Virgen del Rocío Hospital), Sevilla, Spain, ²⁶Department of general Surgery ASst-fbf-sacco, Milan, Italy, ²⁷UOC Chirurgia Generale ed Oncologica, AO San Pio, Benevento, Italy, ²⁸Grenoble-Alpes University Hospital, GRENOBLE, France, ²⁹Department of General, Visceral, Thoracic, Transplant and Pediatric Surgery, University Hospital of Giessen, Giessen, Germany, ³⁰UMHAT EUROHOSPITAL, MEDICAL UNIVERSITY PLOVDIV, Plovdiv, Bulgaria, ³¹University Hospital Centre Zagreb, Zagreb, Croatia, ³²Department of General surgery—Mansoura Faculty of Medicine, Mansoura, Egypt, ³³Department of Surgical Science, University of Rome Tor Vergata, Rome, Italy, ³⁴Department of Management, Ca' Foscari University of Venice, Venice, Italy, ³⁵Trauma center, Rambam medical center, Haifa, Israel, Israel, ³⁶UGI Surgery- Guy's and St Thomas' NHS Foundation Trust, London, United Kingdom, ³⁷Department of Surgery, Maulana Azad Medical College, New Delhi, India, India, ³⁸Department of Clinical and Experimental Sciences, University of Brescia, Brescia, Italy, ³⁹Department of General Surgery, Hadassah Medical Center and Faculty of Medicine, Hebrew University of Jerusalem, Israel, Jerusalem, Israel, ⁴⁰Digestive Surgery, Hospital Universitari Mutua Terrassa, Terrassa, Spain, ⁴¹Surgery, Saint Savvas Cancer Hospital, Halandri—Athens, Greece, ⁴²UnitÀ Operativa Complessa di Chirurgia—Ospedale Santa Maria delle Stelle, Melzo (Milano), Italy, ⁴³Departement of general surgery, Bizerte hospital. faculty of Medecine of Tunis University Tunis El Manar, bizerte, Tunisia, ⁴⁴Department of Surgery, Dirghayu Pokhara Hospital, Pokhara, Nepal, ⁴⁵Department of General and Thoracic Surgery, "SS. Annunziata" University Hospital of Chieti, Chieti, Italy, ⁴⁶General and Digestive Surgery Department, Ramón y Cajal University Hospital, Madrid, Spain, ⁴⁷Secretaria de Salud, Hermosillo, Mexico, ⁴⁸Division of Traumatology, Surgical Critical Care and Emergency Surgery, University of Pennsylvania, Philadelphia, United States, ⁴⁹Sakarya University, Faculty of Medicine, Department of General Surgery, Sakarya, Turkey, ⁵⁰UOC Chirurgia Generale PO D.Camberlingo

Francavilla Fontana, Francavilla Fontana (BR), Italy, ⁵¹Department of General Surgery, Rambam health Care Campus, Haifa, Israel, ⁵²University of Turin, Turin, Italy, ⁵³Chirurgia d'Urgenza e del Trauma, Fondazione Policlinico Gemelli IRCCS, Roma, Italy, ⁵⁴Department of Pain Medicine, National Cancer Center, Aviano, Rome, Italy, ⁵⁵Department of Economics, Ca Foscari University, Venice, Italy, ⁵⁶Banca degli occhi, Mestre, Italy, ⁵⁷Surgical Emergency Unit, Oxford University NHS Trust, Oxford, United Kingdom, ⁵⁸General Surgery Department, Cattinara University Hospital, ASUGI, Trieste, Italy, ⁵⁹Emergency Department Niguarda Hospital, Milano, Italy, ⁶⁰Vascular Surgery Department IRCCS Ca Granda Ospedale Maggiore Policlinico, Milan, Italy, ⁶¹asst santi paolo carlo milano, milano, Italy, ⁶²Thoracic and Vascular surgery Department—Percy military hospital, Clamart, France, ⁶³School of Medicine University of Zagreb, Department of Surgery, University Hospital Centre Zagreb, Zagreb, Croatia, ⁶⁴University Hospital of Ferrara, Surgical Department, Colorectal Unit, Ferrara, Italy, ⁶⁵University of Milan, Department of Biomedical Sciences for Health, IRCCS Policlinico San Donato, Division of General Surgery, Milano (Italy), Italy, ⁶⁶Department of General Surgery University Hospitals Dorset, Poole, United Kingdom, ⁶⁷Digestive Surgery Unit, AOU Careggi, Firenze, Italy, ⁶⁸General Surgery Department, Koutlimbanoio & Triantafylleio General Hospital of Larissa, Larissa, Greece, ⁶⁹Dept of Surgery P. Valdoni—sapienza University, Rome, Italy, ⁷⁰Department of Surgery, "A. Cardarelli" hospital, Naples, Italy, Napoli, Italy, ⁷¹Department of Surgery, Fondazione Policlinico Universitario A Gemelli, IRCCS, Roma, Italy, ⁷²Labasa Hospital Fiji, Labasa, Fiji, ⁷³Hopital "Dr. Alberto Balestrini". University of Buenos Aires, Buenos Aires, Argentina, ⁷⁴Department of Gastrointestinal and Hepatic Diseases, Copenhagen University Hospitals Herlev and Gentofte; Emergency Surgery Research Group Copenhagen (EMERGE), Herlev, Denmark, ⁷⁵Department of Surgical, Oncological and Oral Science, Policlinico "P.Giaccone" Palermo, Italy, ⁷⁶University of Pavia, Corso Str. Nuova, 65, 27100, Pavia, Italy; Unit of General Surgery I, Fondazione I.R.C.C.S. Policlinico San Matteo, Viale Camillo Golgi, 19, 27100, Pavia, Italy, Pavia, Italy, ⁷⁷University of Udine, Udine, Italy, ⁷⁸Elias Emergency University Hospital, Department of Surgery, Bucharest, Romania, ⁷⁹Ospedale San Giovanni Decollato—Andosilla, Civita Castellana, Italy, ⁸⁰Vascular Surgery, University of Padua, Padua, Italy, ⁸¹Department of Surgery, Parc Tauli University Hospital, Sabadell, Spain, ⁸²Department of Economics, Ca Foscari University, Venice, Italy, ⁸³Sakarya University Training and Research Hospital General surgery, Sakarya, Turkey, ⁸⁴Servico de Cirurgia Geral, Hospital de Bragança, Bragança, Portugal, ⁸⁵IRCCS Pascale, Naples, Italy, ⁸⁶Chirurgia Generale, d'urgenza e Nuove Tecnologie, Ospedale Civile di Baggiovara, Modena, Italy, ⁸⁷Chelsea and Westminster Hospital, London, United Kingdom, ⁸⁸Unità operativa complessa chirurgia generale ospedale Umberto I di Enna, Enna, Italy, ⁸⁹General and Emergency Surgery, Milano-Bicocca University, School of Medicine and Surgery, Monza, Italy, ⁹⁰Department of Surgery, Metaxa Cancer Hospital, Piraeus, Greece, ⁹¹Chirurgia Generale uslsdestoscana, Orbetello Grosseto, Italy, ⁹²Asp Cosenza, Cosenza, Italy, ⁹³service de chirurgie digestive, Centre Hospitalier Universitaire Grenoble Alpes, Grenoble, France, ⁹⁴Department of Surgery, Lviv Regional Clinical Hospital, Lviv, Ukraine, ⁹⁵Athens Medical Center, Athens, Greece, ⁹⁶Trauma Center, King Saud Medical City, Riyadh, Saudi Arabia, ⁹⁷University of Foggia-ASL BAT, Andria, Italy, ⁹⁸UOC Chirurgia Generale ASL8 Cagliari, Cagliari, Italy, ⁹⁹Acute Care Surgery and Trauma-ASST GOM Niguarda, Milano, Italy, ¹⁰⁰General Surgery Trauma Team ASST GOM NIGUARDA MILAN, ITALY, Milano, Italy, ¹⁰¹University of Samsun, Samsun Training and Research Hospital, Department of General Surgery, Samsun, Turkey, ¹⁰²General Surgery. Hospital Universitario Son Llatzer, Palma de Mallorca, Spain, ¹⁰³Department of Surgery, Acute care surgery Unit, G. Da Saliceto hospital, Piacenza, Italy, ¹⁰⁴General Surgery, Fondazione Policlinico Universitario Campus Bio-Medico, General Surgery, Fondazione Policlinico Universitario Campus Bio-Medico, Italy, ¹⁰⁵General Surgery Department, Centro Hospitalar do Tâmega e Sousa, Penafiel, Portugal, ¹⁰⁶General Surgery, CHVNG/E,EPE, V.N. Gaia, Portugal, ¹⁰⁷Chirurgia d'urgenza e del trauma, Fondazione Policlinico Universitario A Gemelli IRCCS, Rome, Italy, ¹⁰⁸Health Science Department, Magna Graecia University of Catanzaro, Catanzaro, Italy, ¹⁰⁹Department of Surgery, Spaarne Gasthuis, Haarlem, Netherlands, ¹¹⁰General and Oncologic Surgery, Morgagni—Pierantoni Hospital, AUSL Romagna, Forlì, Italy, ¹¹¹Department of General Surgery, Royal Infirmary of Edinburgh, Edinburgh, United Kingdom, ¹¹²Department of General Surgery. University Sapienza, Rome, Italy, ¹¹³University of Health Science Adana City Training and Research Hospital. General Surgery, Adana, Turkey, ¹¹⁴Cambridge University Hospitals NHS Foundation Trust, Cambridge, United Kingdom, ¹¹⁵Royal Infirmary of Edinburgh, Department of General Surgery and Motol University Hospital, 3rd department of Surgery, EDINBURGH, United Kingdom, ¹¹⁶General

and Digestive Surgery. Hospital Universitario de Jerez de la Frontera, Sevilla, Spain, ¹¹⁷General Surgery Unit, Molifetta Hospital, Molifetta, Italy, ¹¹⁸General surgery I, San Matteo Hospital, University of Pavia, Pavia, Italy, ¹¹⁹San Gerardo Hospital, Monza, Italy, ¹²⁰Surgery Department, Tbilisi State Medical University, Georgia, ¹²¹Department of Neurosurgery, Royal Infirmary Edinburgh, Edinburgh, United Kingdom, ¹²²Department of general surgery, General hospital Novi Pazar, Novi Pazar, Serbia and Montenegro, ¹²³Department of Emergency and Organ Transplantation (DETO), University of Bari, Italy, Bari, Italy, ¹²⁴Department of surgical, oncological and orale sciences—university of Palermo, Palermo, Italy, ¹²⁵University of Catania, Catania, Italy, ¹²⁶AOR San Carlo—Potenza—UOC Chirurgia Generale e Urgenza, POTENZA, Italy, ¹²⁷AORN Cardarelli, ITALIA (IT), Italy, ¹²⁸Dept of General Surgery, San benedetto del tronto Hospital, AV5, ASUR marche, San benedetto del tronto, Italy, ¹²⁹Carol Davila University of Medicine and Pharmacy Bucharest, Emergency Hospital of Bucharest Romania, Bucharest, Romania, ¹³⁰R Adams Cowley Shock Trauma, University of Maryland Medical Center, Baltimore, United States, ¹³¹Department of Emergency and Organ Transplant (DETO), University "Aldo Moro" Medical School of Bari, Bari, Italy, ¹³²Department of Surgical Diseases, University Hospital "Prof. Dr. Stoyan Kirkovich", Stara Zagora, Bulgaria, ¹³³Operative Unit of General Surgery Magenta Hospital, Milan, Italy, Magenta, Italy, ¹³⁴University Hospital Virgen del Rocío, Seville, Spain, ¹³⁵Sindh Institute of Urology and Transplant, Karachi, Pakistan, ¹³⁶Department of Surgery, University of Medicine, Tirana, Albania, ¹³⁷Department of logo Clinical Sciences and Community Health, University of Milan, Italy, ¹³⁸Division of Vascular and Endovascular Surgery, Cardiovascular Department, University Hospital of Trieste ASUGI, Italy, Trieste, Italy, ¹³⁹Department of General Surgery, Virgen del Rocío University Hospital, Seville, Spain, ¹⁴⁰3rd Department of Surgery, 1st Medical Faculty of Charles University, Motol University Hospital, Prague, Czech Republic, ¹⁴¹Department of Surgery, Skane University Hospital, Lund & Malmå, Sweden, ¹⁴²Surgery Lead. PIH Liberia, Harper, Liberia, ¹⁴³Associate Professor of Emergency Medicine, Faculty of Medicine, Suez Canal University, Ismailia, Egypt, ¹⁴⁴Tripoli University Hospital, Tripoli, Libya, ¹⁴⁵University of Newcastle, Department of Traumatology John Hunter Hospital, Newcastle, Australia, ¹⁴⁶Department of Hospital Surgery with the Course of Operative Surgery of Ksma named after I.K. Akhunbaeva, Bishkek, Kyrgyzstan, ¹⁴⁷Emergency/Surgery department—Hospital Viedma, Cochabamba, Bolivia, ¹⁴⁸General, Emergency surgery and New technologies, Baggiovara General Hospital, Modena, Italy, ¹⁴⁹ARNAS Brotzu, Cagliari, Italy, ¹⁵⁰Hospital Universitario Severo Ochoa Leganes. Madrid. Spain, Madrid, Spain, ¹⁵¹Università degli studi di Pavia, Pavia, Italy, ¹⁵²General Surgeon. Fundacion Althaia, Manresa, Spain, ¹⁵³UOC Chirurgia Generale e d'Urgenza Ospedale M. Bufalini Cesena AUSL della Romagna, Cesena, Italy, ¹⁵⁴General Surgery and Trauma Team, ASST Niguarda, Milan, Italy, ¹⁵⁵Swiss Surgical Practice, Lugano, Switzerland, ¹⁵⁶Pediatric Surgery Department, Vittore Buzzi Children's Hospital of Milan, Milan, Italy, ¹⁵⁷Department of Human Pathology of the Adult and Evolutive Age "Gaetano Barresi", General and Emergency Surgery Unit, University of Messina, Messina, Italy, ¹⁵⁸Acute Care Surgery Service of Hospital Vivalde, SĂEO JosĂo dos Campos, Brazil, ¹⁵⁹General Surgery. La Paz University Hospital, Madrid, Spain, ¹⁶⁰Università di Pisa, Pisa, Italy, ¹⁶¹AOU Careggi, Firenze, Italy, ¹⁶²General Surgery Department, Saint Savvas Anticancer Hospital of Athens, Athens, Greece, ¹⁶³Division of Trauma Surgery, University of Campinas, Campinas, Brazil, ¹⁶⁴Chirurgia d'urgenza e del trauma. Fondazione Policlinico Universitario A. Gemelli IRCCS, Rome, Italy, ¹⁶⁵General Surgery I Unit, Fondazione IRCCS Policlinico San Matteo, Università di Pavia, Pavia, Italy, ¹⁶⁶Chirurgia oncologica ARNAS civico Palermo, Palermo, Italy, ¹⁶⁷HPB Unit, Pederzoli Hospital, 37019 Peschiera del Garda, Italy, ¹⁶⁸First Propaedeutic Department of Surgery, Medical School of Athens, National and Kapodistrian University of Athens, Hippocration General Hospital of Athens, Athens, Greece, ¹⁶⁹Department of Abdominal Surgery, Vladimir City Emergency Hospital, Vladimir, Russia, ¹⁷⁰Critical Care Unit, A CoruĂa, Spain, ¹⁷¹IHU Strasbourg, Strasbourg, France, ¹⁷²Department of Medical Science, Oral and Biotechnology of University of Chieti-Pescara "G. d'Annunzio", Chieti, Italy, ¹⁷³Department of Surgery, Aminu Kano Teaching Hospital, Nigeria, Kano, Nigeria, ¹⁷⁴Mansoura faculty of medicine, Man soura, Egypt, ¹⁷⁵Department of Surgery, School of Medical Sciences, Universiti Sains Malaysia, Kubang Kerian, Kelantan, Malaysia, Kota Bharu, Malaysia, ¹⁷⁶Department of surgery university of Manitoba, Winnipeg, Canada, ¹⁷⁷Department of General Surgery Policlinico G.Rodolico, Catania, Italy, ¹⁷⁸Department of Surgery, General Surgery Unit, S.Stefano Hospital, Prato, Italy, ¹⁷⁹Department Valdoni; La Sapienza University of Rome, Roma, Italy, ¹⁸⁰UniversitĂ degli studi di Bari, Bari, Italy, ¹⁸¹Department of Surgery, AO Santa Croce e Carle, Cuneo, Italy, ¹⁸²General Surgery Unit-Parma

University Hospital, Parma, Italy, ¹⁸³UOC Chirurgia Generale e d'Urgenza, Ospedale Santo Spirito in Sassia, Roma, Italy, ¹⁸⁴Department of Surgery, State University of Londrina, Londrina, Brazil, ¹⁸⁵Universidade Federal de Juiz de Fora, Minas Gerais, Juiz de Fora, Brazil, ¹⁸⁶Surgery Unit, Faculdade de Ciências Médicas e da Saúde de Juiz de Fora – Suprema, Brazil, ¹⁸⁷Centro Universitario Padre Albino, Catanduva—SP, Brazil, ¹⁸⁸Sakarya university training and research hospital, Sakarya, Turkey, ¹⁸⁹Department of Surgery, University of Witwatersrand, Johannesburg, South Africa, ¹⁹⁰University Department of Anaesthesiology, Resuscitation and Intensive Care Medicine, Sveti Duh University Hospital, Zagreb, Croatia, ¹⁹¹General surgery, Hospital Universitari Parc Taulí, Sabadell, Spain, ¹⁹²Dipartimento di Scienze Clinico-Chirurgiche, Diagnostiche e Pediatriche, Università degli studi di Pavia, Pavia, Italy, ¹⁹³Department of Upper GI Surgery, University Hospitals Birmingham NHS Foundation Trust, Birmingham, United Kingdom, ¹⁹⁴Emergency surgery department, Careggi University Hospital, Florence, Italy, ¹⁹⁵MU-Plovdiv- Prop. of Surgical Diseases, Plovdiv, Bulgaria, ¹⁹⁶Aden university, Aden, Yemen, ¹⁹⁷Department of Surgery, Kuwaiti Specialized Hospital, Khartoum, Sudan, ¹⁹⁸Dept of Surgery, Nelson R Mandela School of Clinical Medicine, UKZN and Inkosi Albert Luthuli Central Hospital, Trauma and Burns Service, Durban, South Africa, ¹⁹⁹Department of Surgery, Faculty of Medicine and Health Sciences, Universiti Malaysia Sabah, Kota Kinabalu, Sabah, Malaysia, Kota Kinabalu, Malaysia, ²⁰⁰General Surgery, Royal Infirmary of Edinburgh, Edinburgh, United Kingdom, ²⁰¹Dept. of General & Thoracic Surgery, University Hospital of Giessen, Giessen, Germany, ²⁰²University Hospital Giessen, Germany, ²⁰³Cirurgia de trauma, Hospital Central militar, Ciudad de México, Mexico, ²⁰⁴General surgery, CHUD, Universitu of Parakou, Parakou, Benin, ²⁰⁵Hospital Almenara—Lima, Lima, Peru, ²⁰⁶General and Digestive Surgery Unit, Hospital Universitari Vall d'Hebron, Barcelona, Spain, Barcelona, Spain, ²⁰⁷DEPARTMENT OF SURGERY, UNIVERSITI MALAYSIA SARAWAK, KUCHING, Malaysia, ²⁰⁸Manchester Foundation Trust, Manchester, United Kingdom, ²⁰⁹University of Insubria, Varese, Italy, ²¹⁰General Surgery Department—Pederzoli Hospital, Peschiera del Garda, Italy, ²¹¹4th Department of Surgery, Medical School, Aristotle University of Thessaloniki, Thessaloniki, Greece, ²¹²General Surgery, Istanbul Medeniyet University, Istanbul, Turkey, ²¹³Trauma and Orthopaedics Department, Royal Cornwall Hospital, Truro, United Kingdom, ²¹⁴Queen Elizabeth Hospital-Birmingham, Department of Trauma&Orthopaedics, Birmingham, United Kingdom, ²¹⁵Surgical Unit, Faculty of Medicine and Health Sciences, Universiti Sains Islam Malaysia, Nilai, Negeri Sembilan, Malaysia, ²¹⁶Department of Surgery, National Health Insurance Service Ilsan Hospital, Goyang, Korea, South, ²¹⁷General Hospital of Larissa "Koutlimpaneio and Triantafylleio", Larissa, Greece, ²¹⁸Department of Surgery, Tameside General Hospital, Manchester, United Kingdom, ²¹⁹Department of Surgery, Metaxa Cancer Hospital, Piraeus, Greece, ²²⁰University of Pennsylvania; Department of Surgery; Division of Trauma, Surgical Critical Care and Emergency Surgery, Philadelphia, United States, ²²¹Health Sciences University, Kanuni Sultan Süleyman Training and Research Hospital, Istanbul, Turkey, ²²²School of Medicine, National and Kapodistrian University of Athens, Greece, NKUA, Filothei, Greece, ²²³Surgical Clinic "Nikola Spasia", Faculty of Medicine University of Belgrade, Belgrade, Serbia and Montenegro, ²²⁴Department of Surgery, Metaxa Cancer Hospital, Piraeus, Greece, ²²⁵Department of General Surgery, Jubilee Mission Medical College & RI, Thrissur, India, ²²⁶Department of General and Digestive Surgery, Tampere University Hospital (TAUH), Hämeenlinna, Finland, ²²⁷Department of General, Gastrointestinal, Oncologic Surgery and Transplantation, Krakaw, Poland, ²²⁸Hillel Yaffe Medical Center, Hadera, Israel, ²²⁹Portsmouth Hospitals University NHS trust, Portsmouth, United Kingdom, ²³⁰Head surgeon, City Hospital, Mzyr, Belarus, ²³¹Department of Surgery, Inje University Ilsan Paik Hospital, Goyang, Korea, South, ²³²Departments of Surgery and Critical Care and the TeleMentored Ultrasound Supported Medical Interventions (TMUSMI) Research Group, Calgary, Canada, ²³³Fundacion Trauma, Ciudad Autónoma de Buenos Aires, Argentina, ²³⁴Division of General Surgery, Rambam Health Care Campus, Haifa, Israel, ²³⁵Division of General Surgery, Rambam Health Care Campus, Haifa, ²³⁶Fujita Health University Hospital, Toyoake, Japan, ²³⁷Attikon hospital department of general surgery, Athens, Greece, ²³⁸Pengiran Anak Puteri Rashidah Saadatul Bolkih Institute of Health Sciences, Universiti Brunei Darussalam, Bandar Seri Begawan, Brunei, ²³⁹Department of Surgery, University of KwaZulu Natal, Durban, South Africa, ²⁴⁰Department of Surgical Oncology Hellenic Anticancer Hospital, Athens, Greece, ²⁴¹General Surgery, General Hospital of Larissa, Larissa, Greece, ²⁴²UMC Zvezdara, Clinic for Surgery, Belgrade, Serbia and Montenegro, ²⁴³Department of trauma surgery—University of Campinas, Campinas, Brazil, ²⁴⁴Kharkiv National Medical University, Department of Surgery No. 2, Kharkiv, Ukraine, ²⁴⁵Emergency Surgery and Trauma Unit, IRCCS

Humanitas Research Hospital, Rozzano, Italy, ²⁴⁶Emergency and Critical Care Center, Kurashiki Central Hospital, Kurashiki, Japan, ²⁴⁷Surgery department. Urduliz Hospital, Urduliz, Spain, ²⁴⁸Department of Surgery "Pietro Valdoni", Sapienza University of Rome, Rome, Italy, ²⁴⁹Abdominal Center, Helsinki University Hospital and University of Helsinki, Finland, ²⁵⁰Department of Surgery, Buccheri La Ferla Hospital—Palermo, Palermo, Italy, ²⁵¹Department of Surgery, Sant'Eugenio Hospital, Rome, Italy, ²⁵²Department of Surgical Disciplines, Immanuel Kant Baltic Federal University, Regional Clinical Hospital, Kaliningrad, Russia, ²⁵³General Surgery, Hospital Universitario Donostia, Donostia, Spain, ²⁵⁴General Surgery. Corporació Sanitària Parc Taulí, Sabadell, Spain, ²⁵⁵Department of Surgery, Faculty of Medicine Siriraj Hospital, Mahidol University, Bangkok, Thailand, ²⁵⁶Donostia University Hospital, San Sebastian, Spain, ²⁵⁷Department of Surgery, Kavala General Hospital, Kavala, Greece, ²⁵⁸Surgery Department, Mexico City, Mexico, ²⁵⁹General And Emergency Surgery—ASMN IRCCS Reggio Emilia, Reggio Emilia, Italy, ²⁶⁰Universidad Nacional de Asuncion, ASUNCIÓN, Paraguay, ²⁶¹Department of Trauma and Orthopedic Surgery, Insitute for Research in Operative Medicine (IFOM), Cologne-Merheim Medical Center (CMMC), University Witten/Herdecke, Cologne, Germany, ²⁶²Nouvelle Clinique Vert, Geneva, Switzerland, ²⁶³General Surgery ASST Papa Giovanni XXIII, Bergamo, Italy, ²⁶⁴Surgery, Harborview Medical Center, University of Washington, Seattle, WA, United States, ²⁶⁵Department of Sugery, Harborview Medical Center, University of Washington, Seattle, United States, ²⁶⁶Jagiellonian University Medical College, Kraków, Poland, ²⁶⁷General Surgery, Bangalore Medical College & Research Institute, Bangalore, India, ²⁶⁸University Hospital CAREGGI—Digestive Surgery Unit, Firenze, Italy, ²⁶⁹Sakarya University Research and Educational Hospital, Department of General Surgery, Sakarya, Turkey, ²⁷⁰Department of General Surgery, Ospedale degli Infermi, Rivoli, Rivoli, Italy, ²⁷¹Gen and Emer Surg Department, Siena, Italy, ²⁷²Third Department of Surgery, Tzaneio General Hospital, Piraeus, Greece, ²⁷³Emergency Surgery Group—Department of Surgery—University Hospital of Universidade Estadual de Ponta Grossa, Ponta Grossa, Brazil, ²⁷⁴Department of Architecture and Engineering, University of Pavia, Pavia, Italy, ²⁷⁵General Surgery Unit Azienda Ospedaliero Universitaria Policlinico, Bari, Italy, ²⁷⁶Department of General and Digestive Surgery. Hospital Universitario Doctor Peset, Valencia, Spain, ²⁷⁷Department of General and Digestive Surgery. Hospital Universitario Doctor Peset, Valencia, Spain, ²⁷⁸Cesena Hospital, Cesena, Italy, ²⁷⁹Institute of Image-Guided Surgery, IHU-Strasbourg, Strasbourg, France, ²⁸⁰Acute care surgery, Centre Hospitalier Universitaire de Nice, Université Côte d'Azur, Nice, France, Nice, France, ²⁸¹Department of Management, Ca' Foscari University of Venice, ²⁸²General Surgery of Principe de Asturias Teaching, Alcalá de Henares, Spain, ²⁸³Department of Emergency Surgery, Sapienza University of Rome, Rome, Italy, ²⁸⁴UOC CHIRURGIA GENERALE, VITTORIO VENETO, Italy, ²⁸⁵Servisao Cirurgia Geral—Centro Hospitalar Universitario Sao Joao, Porto, Portugal, ²⁸⁶Hospital Universitario Principe de Asturias, Alcalá de Henares, Spain, ²⁸⁷Bagcilar training and research hospital / general surgery department, A*stanbul, Turkey, ²⁸⁸University Hospitals of Geneva, Geneva, Switzerland, ²⁸⁹IRCCS CRO di Aviano, Pain Medicine, Aviano (PN), Italy, ²⁹⁰Ass. Prof. of Surgery, Medical School, University of Athens, Greece, Athens, Greece, ²⁹¹Department of Hepatobiliary and General Surgery, IRCCS Humanitas Research Hospital, Rozzano, Milan, Italy, ²⁹²Department of Surgery "Pietro Valdoni", Sapienza University of Rome, Rome, Italy, ²⁹³DEPARTMENT OF SURGERY AND DEPARTMENT OF TRAUMA AND EMERGENCY, ALL INDIA INSTITUTE OF MEDICAL SCIENCES, BHUBANESWAR, Bhubaneswar, India, ²⁹⁴Trauma and Orthopaedics, Raigmore Hospital, NHS Highlands, Inverness, United Kingdom, ²⁹⁵Trauma and Orthopaedic at Queen Elizabeth hospital, Birmingham, United Kingdom, ²⁹⁶Sandwell and West Birmingham NHS trust, Birmingham, United Kingdom, ²⁹⁷University Hospital Wishaw, Wishaw, United Kingdom, ²⁹⁸Department of Surgery, All India Institute of Medical Sciences, Mangalagiri, Guntur, Andhra Pradesh, India, ²⁹⁹Ernest E Moore Shock Trauma Center at Denver Health, Denver, United States, ³⁰⁰DEPARTMENT OF SURGERY. UNIVESITY HOSPITAL "MARQUES DE VALDECILLA", SANTANDER (CANTABRIA), Spain, ³⁰¹Department of Surgery, and Department of Biomedical and Clinical Sciences, Linköping University, Norrköping, Sweden, ³⁰²Department of Surgery, General University Hospital of Patras, Patras, Greece, ³⁰³Northern Ireland medical and dental training, Belfast, United Kingdom, ³⁰⁴Sapienza University of Rome, Rome, Italy, ³⁰⁵Laboratory of Public Health Indicators Analysis and Health Digitalization, Moscow Institute of Physics and Technology, Dolgoprudny, Russia, ³⁰⁶Trauma Center, Groote Schuur Hospital and University of Cape Town, Cape Town, South Africa, ³⁰⁷Carol Davila University of Medicine and Pharmacy Bucharest, Emergency Hospital of Bucharest

Romania, Bucharest, Romania,³⁰⁸Dipartimento di Medicina e Chirurgia Università di Milano Bicocca, Italy,³⁰⁹Rocky Vista University, Parker, USA,³¹⁰General surgery and Pawi General Hospital, Pawi, Ethiopia,³¹¹Department of Medical and Surgical Sciences and Translational Medicine, Sapienza University of Rome, Rome, Italy,³¹²Lewisham & Greenwich NHS Trust, London, United Kingdom,³¹³Department of Surgery Trinity College Dublin, Dublin, Ireland,³¹⁴Department of Surgery, University College Hospital, Ibadan, Ibadan, Nigeria,³¹⁵General surgery, Ospedale Borgomanero, Borgomanero (NO), Italy,³¹⁶Department of General and Oncologic Surgery. Policlinico San Marco, Zingonia (bg), Zingonia (Bg), Italy,³¹⁷Department of General Surgery, Hospital Bintulu, Bintulu, Malaysia,³¹⁸Urology Unit, Fondazione PTV Policlinico Tor Vergata, Rome, Italy,³¹⁹Research institute of emergency medicine n.a. I. I. Dzhanelidze, department of urgent surgery, Saint-Petersburg, Russia,³²⁰Department of Surgery, School of Medical Sciences, Universiti Sains Malaysia, Kubang Kerian, Kota Bharu, Kelantan, Malaysia, Kota Bharu, Malaysia,³²¹General Surgery, University of Sapienza, Rome, Italy,³²²Department of Medical and Surgical Sciences University of Foggia, Foggia, Italy,³²³Antimicrobial Stewardship Program; Bolzano Central Hospital, Bolzano, Italy,³²⁴Department of clinical medicine and surgery, university of Naples, Federico II, Naples, Italy,³²⁵Dept of Experimental and Clinical Medicine -University of Florence, Careggi University Hospital Florence, Italy, Florence, Italy,³²⁶4th Department of Surgery, University Hospital Bratislava, Bratislava, Slovakia,³²⁷Emergency Department ATTS Spedali Civili di Brescia, Brescia, Italy,³²⁸Department of Medical and Surgical Sciences, University of Padova, Padova, Italy,³²⁹Third Department of Surgery, Athens, Greece,³³⁰Fourth Department of surgery,Attikon University Hospital, Athens, Greece,³³¹1st Surgical Department, General Hospital of Nikaia, Nikaia, Greece,³³²General Surgery, Sant'Anna Hospital, Como, Italy,³³³Dr Sulaiman Al Habib Hospital, Surgical Department, Riyadh, Saudi Arabia,³³⁴Department of Surgery. Santa Casa School of Medical Sciences, Sao Paulo, Brazil,³³⁵Department of Surgery, Western University, London, Canada,³³⁶Nicola Giannettasio Hospital, Corigliano-Rossano, Italy,³³⁷Department of surgery, Baroda Medical College and S.S.G. Hospital, Vadodara, India,³³⁸Royal Infirmary University of Edinburgh, Edinburgh, United Kingdom,³³⁹Department of Medical and Surgical Sciences—University of Foggia, Foggia, Italy,³⁴⁰Division of General Surgery, of Emergency and New Technologies, Baggiovara Hospital, Modena, Italy, Modena, Italy,³⁴¹Department of Economics, Ca Foscari University, Venice, Italy,³⁴²Department of Advanced Medical and Surgical Sciences, Università degli Studi della Campania "Luigi Vanvitelli", Naples, Italy,³⁴³General and Digestive Surgery- University Hospital of Gran Canaria, Las Palmas de Gran Canaria, Spain,³⁴⁴Divisions of Transplantation and Visceral Surgery, Department of Surgery, University of Geneva, Geneva, Switzerland,³⁴⁵General Surgery Emergency and Trauma Surgery, Seville, Spain,³⁴⁶Centro Hospitalar Barreiro Montijo, EPE, Barreiro, Portugal,³⁴⁷Grupo Surgical, Campinas, Brazil,³⁴⁸General surgery, Hospital Universitario Donostia, Donostia, Spain,³⁴⁹Hospital Arnau de Vilanova . Colorrectal surgery, Lleida, Spain,³⁵⁰Department of Medical, Surgical and Experimental Sciences, University of Sassari, Sassari, Italy,³⁵¹Department of emergency surgery, Parma University Hospital, Parma, Italy,³⁵²Delta Hospital, Azienda USL of Ferrara, Department of Surgery, University of Ferrara, Ferrara, Italy,³⁵³General Surgery Residency Program, Tor Vergata University Rome, Rome, Italy,³⁵⁴Azienda Sanitaria Provinciale di Vibo Valentia, Vibo Valentia, Italy,³⁵⁵Department of Obstetrics and Gynecology, Faculty of Medicine, Chulalongkorn University, Bangkok, Thailand,³⁵⁶San Filippo Neri Hospital, ASL Roma 1, Roma, Italy,³⁵⁷Department of Emergency and Organ Transplantation, University Aldo Moro of Bari, Bari, Italy,³⁵⁸General surgery and emergency unit. Department of Surgery. AOU (azienda ospedaliero universitaria) of Modena, Modena, Italy,³⁵⁹Neurosurgery Department, University of Padua, Padua, Italy,³⁶⁰Department of Anesthesia and Intensive Care, Parma University Hospital, Parma, Italy,³⁶¹School of Medicine, National and Kapodistrian University of Athens (NKUA), Athens, Greece,³⁶²Abdominal Surgery Dep., UMC Ljubljana and Medical Faculty Ljubljana, Ljubljana, Slovenia,³⁶³Emergency and General Surgery—Ospedale dell'Angelo—ULSS3 Serenissima, Venezia, Italy,³⁶⁴Calvary Public Hospital, Canberra, Australia,³⁶⁵Department of Emergency Surgery, Cagliari University Hospital, Cagliari, Italy,³⁶⁶Department of Medical, Surgical and Experimental Sciences, University of Sassari, Sassari, Italy,³⁶⁷General Surgery, Ospedale Policlinico-Vittorio Emanuele, Catania, Italy,³⁶⁸Department of Emergency and Organ Transplant (DETO), University "Aldo Moro" Medical School of Bari, Bari, Italy,³⁶⁹Sapienza University of Rome, department of General Surgery and surgical specialties Paride Stefanini, Rome, Italy,³⁷⁰Trauma Surgery, Hospital Santo Tomas, Panama, Panama,³⁷¹Research Unit fo Surgery, Odense University Hospital; Southern University of Denmark, Odense, Denmark,³⁷²Universiti Sains Islam Malaysia, Nilai, Malaysia,³⁷³Cirurgia, Hospital Prof Doutor Fernando Fonseca, Amadora, Portugal,³⁷⁴Surgical Department, Universiti Sains Malaysia and Hospital USM, Kubang Kerian, Malaysia,³⁷⁵Anadolu Medical Center, Kocaeli, Turkey,³⁷⁶Department of General, Visceral, Thoracic, Transplant and Pediatric Surgery, University Hospital of Giessen, Giessen, Germany,³⁷⁷Dep. of General, Visceral and Oncologic Surgery, Hospital and Clinics Wetzlar, Germany, Wetzlar, Germany,³⁷⁸Division of Trauma, Emergency Surgery, and Surgical Critical Care, Boston, United States,³⁷⁹University of Rome Tor Vergata, Roma, Italy,³⁸⁰Surgical Research Fellow. Research Institute Against Digestive Cancer, IRCAD, Strasbourg, France, Strasbourg, France,³⁸¹Hospital del Trabajador, Surgery Department, Santiago, Chile,³⁸²Department of General Surgery, Valduce Hospital, Como, Italy,³⁸³UO Chirurgia Generale, Ospedale Ceccarini, Riccione, Italy,³⁸⁴General Surgery, ASST Valle Olona, Busto Arsizio, Italy,³⁸⁵Department of Surgery Universiti Sains Malaysia, Kota Bharu, Malaysia,³⁸⁶Department of General and Emergency Surgery, San Filippo Neri Hospital, Rome, Italy, Roma, Italy,³⁸⁷Neuroscience Institute, Universidad El Bosque, Cali, Colombia,³⁸⁸Endocrine and Bariatric-Metabolic Surgery Department, Fuenlabrada University Hospital, Madrid, Spain,³⁸⁹Research Institute at Medical Institute Plovdiv, General Surgery Department, Plovdiv, 4000, Bulgaria,³⁹⁰Hospital Vicente Corral Moscoso, Universidad del Azuay, Cuenca, Ecuador,³⁹¹Department of visceral surgery. Military teaching hospital., Dakar, Senegal,³⁹²Consultant General surgeon,University hospitals, Leicester, United Kingdom,³⁹³Trauma Team, San Carlo Borromeo Trauma Center, ASST Santi Paolo e Carlo, Milan, Italy,³⁹⁴Hospital Universitario Virgen del Rocío, Sevilla, Spain,³⁹⁵Consorci Sanitari Integral—Hospital Moises Broggi Sant Joan, Sant Joan Despà, Spain,³⁹⁶Cesena Hospital, Cesena, Italy,³⁹⁷Macerata hospital,³⁹⁸General and Oncological Surgery Unit, Santa Croce and Carle Hospital, Cuneo, Cuneo, Italy,³⁹⁹Ehime University Department of Emergency and Critical Care, TOON, Japan,⁴⁰⁰Surgery Department, Putyla District Hospital, Putyla, Ukraine,⁴⁰¹Western michigan University Homer Stryker MD School of Medicine, Kalamazoo, United States,⁴⁰²University of Turin, Turin, Italy,⁴⁰³FIRST DEPARTMENT OF SURGERY, NATIONAL AND KAPODISTRIAN UNIVERSITY OF ATHENS, ATHENS, Greece,⁴⁰⁴AOUI Verona Chirurgia Generale E dell'Esofago e dello Stomaco, Verona, Italy,⁴⁰⁵IHU-Strasbourg, Institute of Image-Guided Surgery / Strasbourg University Hospitals, Department of General, Digestive and Endocrine Surgery, Strasbourg, France,⁴⁰⁶Hospital de Clinicas. Universidad Nacional de Asuncion, San Lorenzo, Paraguay,⁴⁰⁷Agios Andreas General Hospital of Patras, Patras, Greece,⁴⁰⁸DIMEC, University of Bologna, Bologna, Italy,⁴⁰⁹Department of Surgery. Miguel Servet University Hospital, Zaragoza, Spain,⁴¹⁰General Surgery, Tan Tock Seng Hospital, Singapore, Singapore,⁴¹¹Surgical Infections Department Emergency Care Research Institute n.a. I.I.Djanelidze, Saint-Petersburg, Russia,⁴¹²4th Surgical Department, University Hospital Attikon, Athens, Greece,⁴¹³Universidade Federal de Juiz de Fora Campus Governador Valadares—UFJF/GV (Federal University of Juiz de Fora) and Universidade Vale do Rio Doce—Univale (Vale do Rio Doce University)., Governador Valadares—MG, Brazil,⁴¹⁴Department of Surgical Sciences, University of Roma Tor Vergata, Rome, Italy,⁴¹⁵Thammasat University Hospital, Pathum Thani, Thailand,⁴¹⁶University Hospital Eurohospital, Plovdiv, Bulgaria,⁴¹⁷Department of Medical and Surgical Sciences, University of Bologna, Forli, Italy,⁴¹⁸Ospedale Sacra Famiglia Fatebenefratelli, Erba, Italy,⁴¹⁹Department of Hospital Surgery with the Course of Operative Surgery of KSMA named after I.K. Akhunbaeva, Bishkek, Kyrgyzstan,⁴²⁰Department of Gastrointestinal Surgery, Stavanger University Hospital, Norway,⁴²¹Surgical Department, Giannitsa General Hospital, Giannitsa, Pella, Greece,⁴²²East Carolina University, Brody School of Medicine, Greenville, NC, United States,⁴²³University of Alberta, Edmonton, Canada,⁴²⁴Department of General Surgery, Faculty of Medicine and Health Sciences, Universiti Malaysia Sabah, Kota Kinabalu, Sabah, Malaysia, Kota Kinabalu, Sabah, Malaysia, Malaysia,⁴²⁵Chernivtsi Regional Emergency Hospital, Chernivtsi, Ukraine,⁴²⁶Bukovinian State Medical University, Chernivtsi, Ukraine,⁴²⁷Acute Care Surgery, Hamad Medical Corporation, Doha, Qatar,⁴²⁸Surgery Department. Virgen del Rocío University Hospital, Sevilla, Spain,⁴²⁹Gastrointestinal Surgery IRCCS San Raffaele Scientific Institute, Milan, Italy,⁴³⁰Asst Monza—Ospedale San Gerardo, Colorectal surgery unit, Monza, Italy,⁴³¹Department of Surgery, Radboudumc, Nijmegen, Netherlands,⁴³²HSAJB, Johor Bahru, Malaysia,⁴³³Emergency Surgery Department, Parma University Hospital, Parma, Italy,⁴³⁴Department of Medical and Surgical Sciences—University of Foggia, Foggia, Italy,⁴³⁵Università degli studi di Pavia, Italy,⁴³⁶Emergency Surgery Unit & Trauma Center, Pisa University Hospital, University of Pisa, Pisa, Italy,⁴³⁷Department of Surgery. University Hospital Aintree, Liverpool, United Kingdom,⁴³⁸Digestive and Emergency

Surgery Unit, Azienda Ospedaliera S.Maria, Terni, Italy,⁴³⁹Departamento de cirurgia—UNIFIPA, Catanduva—SP, Brazil,⁴⁴⁰Dept. Of Trauma, University Hospital Zurich, Zurich, Switzerland,⁴⁴¹Department of Surgery, Aretaieio University Hospital Athens, Athens, Greece,⁴⁴²Abdominal Center, Helsinki University Hospital and University of Helsinki, Helsinki, Finland,⁴⁴³Department of Emergency and Organ Transplant (DETO), University "Aldo Moro" Medical School of Bari, Bari, Italy,⁴⁴⁴General Surgery, Augusta Hospital, Syracuse, Italy, Italy,⁴⁴⁵Chirurgia Tratto Alimentare, IRCCS Policlinico Sant'Orsola, Bologna, Italy,⁴⁴⁶UGI Senior Clinical Fellow,Department of Surgery,Royal Infirmary of Edinburgh, Edinburgh, United Kingdom,⁴⁴⁷General Surgery Unit, Azienda Ospedaliera Universitaria Policlinico di Bari, Bari, Italy, Italy,⁴⁴⁸Azienda ospedaliera universitaria Verona, Verona, Italy,⁴⁴⁹Hospital Maciel, Montevideo, Uruguay,⁴⁵⁰Sismanoglio General Hospital, Athens, Athens, Greece,⁴⁵¹General and Digestive Surgery, Fundacio Sanitaria Mollet, Mollet del Valles, Spain,⁴⁵²Chirurgia 3, AOU Città della Salute e della Scienza di Torino, Torino, Italy,⁴⁵³San Marco Hospital GSD, Zingonia (BG), Italy,⁴⁵⁴Department of Special surgery, Medical university Plovdiv, Plovdiv, Bulgaria,⁴⁵⁵GENERAL SURGERY DEPARTMENT-GALDAKAO UNIVERSITY HOSPITAL/BIOCUCES BIZKAIA HEALTH RESEARCH INSTITUTE, GALDAKAO-USANSOLO, Spain,⁴⁵⁶Department of gastroenterology and alimentary tract surgery, Tampere University Hospital, Tampere, Finland,⁴⁵⁷1st Department of surgery, Laiko General hospital, Athens, Greece,⁴⁵⁸4th Surgical Department, Attikon Hospital, National and Kapodistrian University of Athens, Haidari-Athens, Greece,⁴⁵⁹IHU-Strasbourg, Institute of Image-Guided Surgery, Strasbourg, France,⁴⁶⁰Critical Care Unit, Complejo Hospitalario Universitario A Coruna, A Coruña, Spain,⁴⁶¹Harvard Medical School, Boston, USA,⁴⁶²Hospital Universitario Austral, Pilar, Argentina,⁴⁶³Institute of Image-Guided Surgery, IHU Strasbourg, Strasbourg, France,⁴⁶⁴Department of Medical and Surgical Sciences and Advanced Technologies, University of Catania, Italy, Catania, Italy,⁴⁶⁵General Surgery 1, Fondazione IRCCS Policlinico San Matteo, Pavia, Pavia, Italy,⁴⁶⁶Professor of Surgery at Universitat autonoma de Barcelona Consultant Surgeon at Vall Hebron Hospital Endocrine-Metabolic and Bariatric Unit. Robotic Surgery. Vall Hebron Barcelona Hospital Campus. Pg. De la Vall d'hebron, 119-129 080035 Barcelona, BARCELONA, Spain,⁴⁶⁷Chirurgia Generale d'Urgenza e PS—AOU Città della Salute e della Scienza, Torino (Turin), Italy,⁴⁶⁸Department of Anesthesia and Critical Care, ARCO Roma, IRCCS Ospedale Pediatrico Bambino Gesù, Rome, Italy,⁴⁶⁹Department of General, Oncological, Metabolic and Thoracic Surgery, Military Institute of Medicine, Warsaw, Poland,⁴⁷⁰Department of Surgery, Faculty of Medicine Siriraj hospital, Mahidol university, Bangkok, Thailand,⁴⁷¹Department of Visceral Surgery and Medicine, Inselspital, Bern University Hospital, University of Bern, Bern, Switzerland,⁴⁷²Department of General Surgery, Forth Valley Royal Hospital, Larbert, United Kingdom,⁴⁷³Department of Surgery, Spaarne Gasthuis, Hoofddorp, The Netherlands,⁴⁷⁴Duke-National University of Singapore, Singapore, Singapore,⁴⁷⁵Department of Surgery, University Hospital of Heraklion Crete, Heraklion Crete, Greece,⁴⁷⁶Trauma surgery, Gachon University Gil Medical center, Incheon, Korea, South,⁴⁷⁷Royal Infirmary University of Edinburgh, Edinburgh, United Kingdom,⁴⁷⁸Department of General & Minimal Access Surgery, KIMS-Kerala Institute of Medical Sciences, Trivandrum, India,⁴⁷⁹General Surgery, St.Andrew Hospital, Patra, Greece,⁴⁸⁰Chirurgia Generale, ospedale San Bortolo, Vicenza, Italy,⁴⁸¹Department of Surgery, School of Medical Sciences, Universiti Sains Malaysia, Kelantan, Malaysia,⁴⁸²Departamento de Cirugia, Sociedad de Lucha Contra el Cancer—SOLCA, Guayaquil, Ecuador,⁴⁸³Third surgical department -Tzaneio hospital, Piraeus, Greece,⁴⁸⁴Department of Orthopaedic and Trauma Surgery, Campus Bio-Medico University Hospital, Rome, Italy,⁴⁸⁵Università di Pavia, Unit of general surgery, Pavia, Italy,⁴⁸⁶Department of Economics, Ca Foscari University, Venice, Italy,⁴⁸⁷4th Surgical Clinic Aristotle University of Thessaloniki, Thessaloniki, Greece,⁴⁸⁸Department of Surgical, Oncological and Gastroenterological Sciences-Urological Clinic, University of Padua, Padua, Italy,⁴⁸⁹ULSS5 Polesana Department of General Surgery, Santa Maria della Misericordia Hospital, Rovigo, Italy

Author contributions

LC and FDM conceived the idea of the study. LC and FDM wrote the research protocol. LC, FDM, LA, FaCa, SD, HK, TJL, and PP reviewed the research protocol. LC and FDM took care of the data collection. LC, DP, and FDM took care of the data analysis. LC, FDM, DP, and TJL wrote the first draft of the manuscript. VA, LA, JB, WB, GB, FaCa, FeCo, SD, BDS, IF, PF, GiM, GRM, JM, MM, PP, FR, AV, and HK critically reviewed the manuscript. All authors approved the final version of the article.

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Declarations

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Consent for publication

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Competing interests

The authors declare that they have no competing interests in this article.

Author details

¹Department of Clinical, Diagnostic and Pediatric Sciences, University of Pavia, Via Alessandro Brambilla, 74, 27100 Pavia, PV, Italy. ²General Surgery, IRCCS Policlinico San Matteo Foundation, Pavia, Italy. ³ITIR – Institute for Transformative Innovation Research, University of Pavia, Pavia, Italy. ⁴Department of Neurosurgery, ASUFC Santa Maria Della Misericordia, Udine, Italy. ⁵Department of Management, Ca' Foscari University of Venice, Venice, Italy. ⁶Bufalini Hospital, AUSL Romagna, Cesena, Italy. ⁷Department of Surgery, University of Florida Health, Gainesville, FL, USA. ⁸Division of Trauma and Acute Care Surgery, Scripps Memorial Hospital La Jolla, La Jolla, CA, USA. ⁹Department of HPB Surgery, Pederzoli Hospital, Peschiera del Garda, Italy. ¹⁰General, Emergency and Trauma Surgery Department, Pisa University Hospital Pisa, Pisa, Italy. ¹¹Department of Economics and Management, University of Pavia, Pavia, Italy. ¹²Department of Emergency, Digestive and Metabolic Minimally Invasive Surgery, Poissy and Saint Germain en Laye Hospitals, Poissy, France. ¹³IRCCS Policlinico San Matteo Foundation, Pediatric Clinic., Pavia, Italy. ¹⁴Department of Civil Engineering and Architecture, University of Pavia, Pavia, Italy. ¹⁵Department of Surgery, Careggi University Hospital, Florence, Italy. ¹⁶Humco Srl, Venice, Italy. ¹⁷General Direction, ASL BAT (Health Agency), Andria, Italy. ¹⁸Department of Political and Social Sciences, University of Pavia, Pavia, Italy. ¹⁹Bureau of the Presidency, IRCCS Policlinico San Matteo Foundation, Pavia, Italy. ²⁰Harvard Medical School, Boston, MA, USA. ²¹Division of Trauma, Emergency Surgery, and Surgical Critical Care, Massachusetts General Hospital, Boston, MA, USA.

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