



Ethical attitudes in neurosurgery at the height of the COVID-19 pandemic

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1. Introduction

The COVID-19 pandemic - the likes of which no healthcare provider has experienced in recent decades - has catapulted our society in uncharted territory. As countless people got infected, a sustained and dramatic increase in demand for healthcare ensued. Scarcity arose when demand exceeded the availability of healthcare resources. This applies to the financial, logistical and “architectural” constraints of the healthcare system, as well as its most valuable inelastic asset of skilled care providers and supporting staff (Myles and Maswime, 2020; World Health Organization, 2020).

As governments and hospital administrators across the globe mustered resources to combat the influx of COVID-19 cases in March and April of 2020, many neurosurgeons saw their working conditions drastically altered. Whilst some were redeployed as first-line workers, the majority was forced to postpone or cancel elective surgeries. Several government agencies and professional organisations such as the ACS and EANS, issued recommendations regarding triaging and scheduling of elective surgeries (American College of Surgeons, 2020; Belgian Society of Neurosurgery, 2020; European Association of Neurosurgical Societies, 2020). Notwithstanding efforts to preserve essential supplies, scarcity has prompted several ethical questions regarding the allocation and distribution of healthcare-related resources (White and Lo, 2020).

We aimed to survey neurosurgical practice and ethical attitudes during the onset of the COVID-19 pandemic on. We explored whether consensus exists amongst neurosurgeons as to what substitutes an essential intervention with regard to restrictions on elective surgeries. Also, we examined how neuro-ethical decision-making was influenced by the ongoing pandemic.

2. Methods

2.1. Survey

An invitation to an online questionnaire (see Supplementary Information) was distributed to neurosurgeons via the mailing list of the EANS. This survey went live on March 30, 2020. Responses submitted until May 31, 2020, were included in the present analysis.

Participants were questioned about their career status, the size of their practice, the adoption of national or regional measures, restrictions and guidelines. To allow for controlling for local health care demand, we asked respondents to estimate the remaining capacity of their local ICU and regular wards.

In three parts, respondents were confronted with hypothetical cases, accompanied by a preamble setting the context of the scenarios. The first part (A) comprised general management of typical neurosurgery cases given the restrictions on elective surgery in force at the time. A second group of cases (B1–B3) inquired about the attitude in emergent cases where a decision to operate or not had to be made within a context of ongoing high demand for ICU beds.

Lastly (cases C1–C3), participants were asked whether they would - in a context where demand exceeds supply and no alternatives are possible - withdraw mechanical ventilation in a given patient to benefit another. Respondents had to the option to reallocate mechanical ventilation to the other patient, keep for the current patient or to flip a coin, i.e. random allocation. These vignettes were specifically constructed to have an equal theoretical risk for unfavourable outcome; though, these risks were not explicitly stated. In addition, respondents were asked to explain what had driven their decision.

The case vignettes were inspired by daily practice and discussed with

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Abbreviations

95%CI	95% confidence interval
AANS	American Association of Neurological Surgeons
ACS	American College of Surgeons
COVID-19	Coronavirus disease 19
EANS	European Association of Neurosurgical Societies
ICU	intensive care unit
IQR	interquartile range
WFNS	World Federation of Neurosurgical Societies

four attending neurosurgeons during the pilot phase of the study. Any ambiguity with regards to the wording or case characteristics was resolved.

2.2. Statistical analysis

Descriptive statistics are reported as counts and proportions. A percentage agreement was calculated for each of the hypothetical questions as the proportion of response pairs in exact agreement with the total number of pairs. An agreement coefficient was calculated as the difference between observed pairs in agreement and expected pairs in agreement by chance (a uniform distribution across answer options) divided by 1 minus the expected pairs in agreement. This coefficient ranges from zero (uniform distribution of answers) to one (perfect agreement amongst respondents), thus correcting for chance and the number of available options.

We performed a logistic regression analysis to identify predictors of the decision making in cases B1–B3 and C1–C3. To this effect, the response variable was reduced and dichotomised. We examined the influence of COVID burden, expressed as the number of new cases per million inhabitants for the country of the respondent on the day of submission (Roser et al., 2020). The influence of certification, years of practice, types and size of practice and remaining ICU capacity was evaluated with a Fisher Exact test for nominal variables and a linear by linear test when comparing two ordinal variables. A Cochran-Armitage test was used for ordinal predictors and a binary outcome variable. A sample size of 63 would be required to discern a significant difference in proportions with an effect size of 0.5 at a power of 0.80 and a significance level of 0.05. Statistical analysis was performed with R (version 3.6.3, 2020, R Core Team, Vienna, Austria).

3. Results

3.1. Respondents

One-hundred and fifteen neurosurgeons answered the survey of whom 29 (25%) were trainees. The number of EANS individual members is estimated at 1500. This yields a response rate of approximately 7%. The majority of respondents practice in Europe or Australia (see Table 1). Among the participants who are board-certified neurosurgeons, approximately half work in an academic hospital (n = 41), a third in a non-academic teaching hospital (n = 28) and the remainder in private practice (n = 16). The number of years since certification and the size of their departments were distributed evenly across the spectrum (see Fig. 1). At the time of the survey, all (n = 107, 95%) or some (n = 6, 5%) non-essential visits and procedures had to be postponed. The mean COVID-19 burden was 67,4 new cases per million inhabitants (IQR 13.2–100).

3.2. Management and triaging of neurosurgical cases

The preferred management strategy of the respondents for the various

Table 1

Respondents grouped by country of practice and the average number of new cases per millions of inhabitants during the survey period. *Global incidence.

Country	Number of respondents	COVID-19 burden (smoothed daily average of new cases per million)
Belgium	35	70.1
Australia	13	17.5
Italy	10	39.6
France	7	37.9
Germany	6	26.0
Greece	4	3.0
Switzerland	4	34.7
Portugal	3	43.4
Serbia	3	25.3
Austria	2	17.5
Bosnia and Herzegovina	2	10.9
Hungary	2	5.8
United Kingdom (UK)	2	54.3
Other	21	10.7*

hypothetical cases they were presented with are shown in Table 2 and Fig. 2. The strongest agreement among respondents existed for the cases concerning oncologic disease and withdrawal of care in the quadriplegic patient (Case C2). In contrast, cases concerning intracranial haemorrhage or traumatic brain injury proved the most controversial. The measure of agreement did not change meaningfully when excluding trainees save for two instances. The first is the aforementioned case C2. Secondly, for the pituitary case (A9) trainees were more likely to opt for a transcranial approach whereas certified surgeons opted for watchful waiting or transnasal procedure after a negative PCR-test (Fisher Exact $p = 0.0106$).

A majority of respondents considered it essential to manage enhancing intracerebral lesions, suggestive of supratentorial metastasis or high-grade glioma, surgically at the earliest time possible (73% for case A2, 89% for case A7). In contrast, slow-growing lesions without symptoms, such as meningioma and pituitary adenoma, and an asymptomatic medium-sized aneurysm would be postponed until after the pandemic by a large majority of respondents (A4 aneurysm 65%, A8 meningioma 85%, A9 pituitary adenoma 76%). Likewise, lumbar disc herniation with preserved motor function would be postponed by 70% of respondents. However, a sizable portion (28%) considers that intractable sciatic pain merits early surgery during the pandemic restrictions.

Fig. 2 shows the preferred attitude concerning neurocritical cases (cases B) and the reallocation of scarce mechanical ventilation (cases C). Fourteen respondents (12%) and 29 respondents (25%) answered equivocally on cases C1–C3 to continue or to withdraw mechanical ventilation, respectively.

3.2.1. Influencing factors

Table 3 lists the number of mentions of specific themes in the open-ended questions as to what had influenced the respondents' answers for cases C1–C3.

Fig. 3 demonstrates the influence of career status, remaining ICU capacity for non-COVID cases, practice type and practice size on the decision making in cases B1–B3 and C1–C3. Larger practice size was significantly associated with a non-surgical attitude in cases B1 and B2 (Linear-by-linear test $p = 0.028$ and 0.005 , respectively). Paradoxically, a higher COVID burden was associated with the attitude to operate in case B3 (OR 0.982, 95%CI 0.97–0.983, $p = 0.003$). In our data, we found no other significant effect of COVID burden on neurosurgical decision making. Trainees were far more likely (93% versus 77% of board-certified respondents) to withdraw ventilation for the quadriplegic patient of case C2 (Fisher Exact $p = 0.0157$, see Fig. 3).

3.3. Guidelines

A majority of respondents (59%) received guidelines regarding

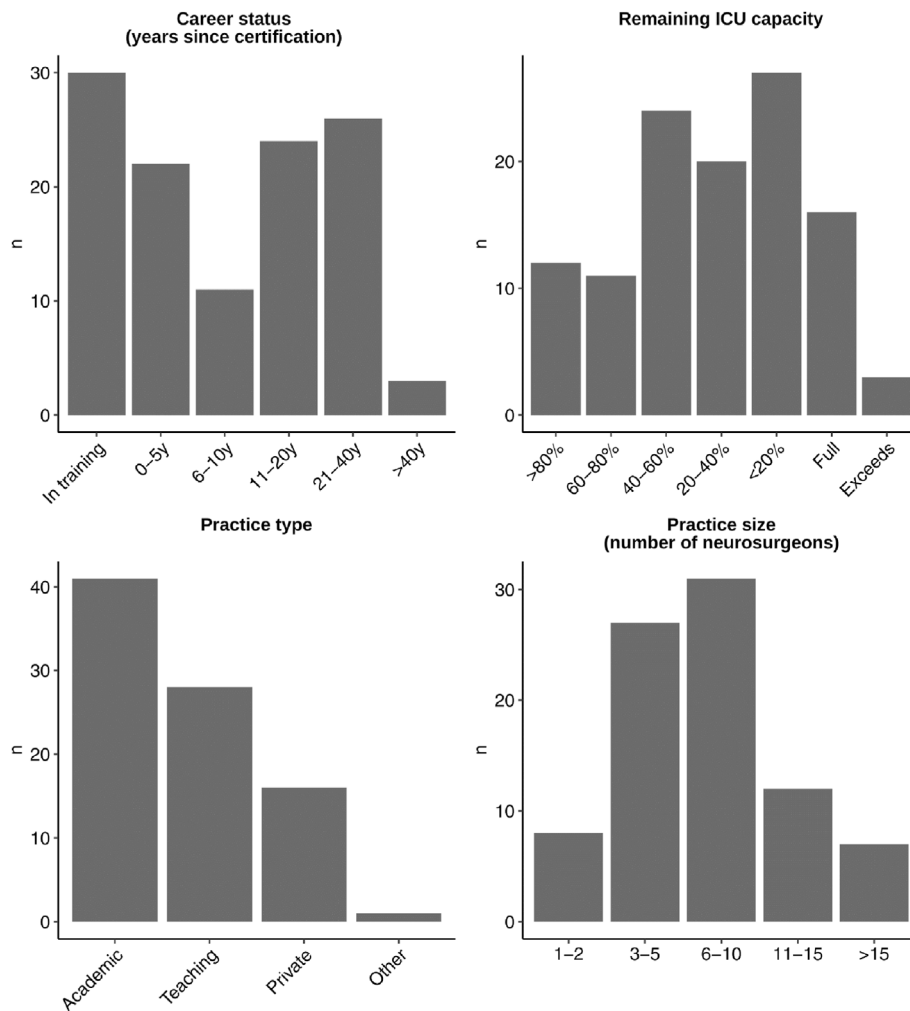


Fig. 1. Characteristics of respondents of the survey. **Top left** Experience (years since certification). **Top right** Remaining ICU capacity. **Bottom left** Type of practice (board certified only). **Bottom right** Size of practice (board certified only).

postponement from their hospital administration and to a lesser extent issued by professional societies or government agencies. These guidelines only seldom included an exhaustive listing of essential procedures (see Fig. 4).

4. Discussion

4.1. Impact of COVID-19 pandemic on neurosurgery

At the height of the pandemic, operative volumes dropped significantly due to restrictions imposed by governments, professional societies or hospital administrations (Fontanella et al., 2020). Many neurosurgical societies were quick to publish guidelines regarding the triage of cases. ACS and EANS guidelines were issued on March 13 and March 31, respectively (American College of Surgeons, 2020; European Association of Neurosurgical Societies, 2020). Yet, these publications seem to not have reached the majority of neurosurgeons.

Other surveys have addressed the ranking of risk of postponement and the impact of the pandemic on professional conditions (Jean et al., 2020; Mathiesen et al., 2020; Soriano Sánchez et al., 2020). Comparing our results, we found similar trends with a high degree of agreement that fast-evolving oncologic disease (e.g. high-grade glioma and metastatic disease) constitutes an essential procedure. This provides external validity to our survey methodology. In contrast, rather than asking respondents to attribute an abstract measure of acuity and urgency, we provided specific management options and time frames.

4.2. Ethical issues in the allocation of neuro-critical care

Neurosurgeons are faced with moral dilemmas on a daily basis. These are resolved, preferably, through multidisciplinary discussion, guided by weighing risks and best interests, informed by advance care directives or by proxy, all whilst honouring patient autonomy (Cooke, 2010; McMillan and Hope, 2010; Persad et al., 2009).

As healthcare predominantly draws funding from the social security system, physicians are prompted to consider cost-effectiveness and just allocation of resources. In general, the concept of rationing is frowned upon as it entails withholding potentially beneficial treatments for some patients (Scheunemann and White, 2011). Yet, this consideration becomes pressing in times of scarcity. Under such conditions, the attitude to continue futile treatment merely to preserve life - without considering prognosis, necessarily results in avoidable harm to another patient (Honeybul et al., 2013). Multiple guidelines assert that a decision to withdraw a scarce resource to benefit others is not an act of homicide or malpractice, nor should it require the patient's or proxy's consent. However, a solid legal framework is not universally established (Cohen et al., 2020; Ministry of Health and NSW, 2010; Rosenbaum et al., 2011; White and Lo, 2020). As such, the physician has to resolve the ethical standoff between his obligation to care for the patient before him and the preservation of resources for a future patient. This ultimately pertains to a consideration of justice or - in a more colloquial term - *fairness* (McMillan and Hope, 2010).

Scarcity of vital resources already existed before the onset of the

Table 2

Counts and percentage of answers for each of nine case vignettes. Percentage agreement is the proportion of pairs in agreement to the total number of possible pairs. The coefficient is this proportion corrected for chance and the number of possible answers. Therefore, the latter is more appropriate for comparison between cases. A value closer to 100% or 1, respectively, indicates better agreement amongst respondents.

Case Percentage agreement Coefficient	Description (original question in Supplementary Informations)	Options	N (%)
<u>A1</u> 61.2% 0.42	Would you consider operating an essential but non-immediately life-threatening case without a surgical mask?	Yes Yes, except for permanent implants No	14 (12%) 12 (10%) 89 (77%)
<u>A2</u> 54.3% 0.32	Management of an enhancing right frontal mass lesion with important perilesional edema causing mild left hemiparesis without fever or systemic signs of infection.	Manage with steroids (postponing surgery) Manage surgically at the earliest time possible Manage without steroids (postponing surgery) Other	21 (18%) 84 (73%) 8 (7%) 2 (2%)
<u>A3</u> 23.3% 0.11	Cranial vault reconstruction for an infant aged 8 and 1/2 months with isolated metopic craniosynostosis with marked trigonocephalic deformation and normal neurological examination and fundoscopy.	Essential, today or tomorrow Essential, within one week Essential, within two weeks Essential, within a month Not essential, plan after restrictions Not essential, unless intracranial hypertension Refer to a pediatric neurosurgical centre Other	0 (0%) 2 (2%) 3 (3%) 16 (14%) 31 (27%) 37 (32%) 25 (22%) 2 (2%) 8 (7%)
<u>A4</u> 45.7% 0.33	Management of an unruptured intracranial aneurysm on the left posterior communicating artery measuring 16 mm in a 66-year-old female with medically managed hypertension	Essential, today or tomorrow Essential, within one week Essential, within two weeks Essential, within a month Not essential, plan after restrictions	7 (6%) 4 (3%) 25 (22%) 75 (65%)
<u>A5</u> 31.9% 0.19	Management of normal pressure hydrocephalus in a 71-year-old male with progressive cognitive problems, gait disturbance and urinary incontinence for several months and suggestive tap test	Essential, today or tomorrow Essential, within one week Essential, within two weeks Essential, within a month Not essential, plan after restrictions Not essential, outpatient lumbar taps	2 (2%) 4 (3%) 7 (6%) 15 (13%) 54 (47%) 34 (29%)
<u>A6</u> 37.5% 0.17	Management of 29-year-old female with lumbar disc herniation causing sciatic pain refractory to pain relief, NSAIDs and epidural steroid. Motor function preserved, only slight hypoesthesia.	Admit for IV pain relief Admit for IV relief, consider surgical decompression within 48 h Discharge with pain relief, postponing surgery* Discharge with pain relief, postponing surgery** *earlier if any degree of motor weakness would develop **even if mild motor weakness, MRC 3/5, would develop	2 (2%) 32 (28%) 60 (52%) 21 (18%) — —
<u>A7</u> 79.2% 0.73	Enhancing lesion with central necrosis in the right frontal region, suggestive for high-grade	Manage with steroids and anti-epileptic drugs (postponing surgery)	3 (3%) 2 (2%)

Table 2 (continued)

Case Percentage agreement Coefficient	Description (original question in Supplementary Informations)	Options	N (%)
<u>A8</u> 46.3% 0.38	glioma found after a generalised epileptic seizure in a 39-year-old male. Parafalcine meningioma, which demonstrated growth, attached to the lateral wall of the superior sagittal sinus in a 56-year-old female without symptoms.	Manage with anti-epileptic drugs only (postponing surgery) Manage surgically at the earliest time possible (avoiding or quickly tapering steroids) Manage surgically only in case of recurrent epilepsy despite management with anti-epileptic drugs and/or steroids. Surgical resection is essential and urgent, to be scheduled within 2–3 months Surgical resection is not urgent, can be scheduled after restrictions are lifted Stereotactic radiosurgery or fractionated radiotherapy, to be scheduled within 2–3 months Stereotactic radiosurgery or fractionated radiotherapy, can be scheduled after restrictions are lifted, Continue watchful waiting with new MRI in 3–6 months Other	102 (89%) 8 (7%) 5 (4%) 76 (66%) 4 (3%) 2 (2%) 20 (17%) 8 (7%)
<u>A9</u> 58.2% 0.48	Pituitary adenoma elevating the optic chiasm with normal ophthalmologic examination and no symptoms.	Proceed with transnasal procedure as planned Perform a CT thorax pre-operatively Perform one or more RT-PCR Opt for transcranial approach Postpone surgery with ophthalmologic control	2 (2%) 3 (3%) 15 (13%) 8 (7%) 87 (76%)

current pandemic. A familiar example is the allocation of organ transplants. Various allocation schemes have been devised, each based on one or more ethical frameworks. The fairness of such principles (e.g. first-come, first-served; sickest-first; maximising benefit; expected outcome; reciprocity and lottery) applied to a global pandemic has been discussed at length by others (Emanuel et al., 2020; White and Lo, 2020). A more concise toolkit for neurosurgical triage has been presented on behalf of the Ethico-Legal Committee of the EANS (Hulsbergen et al., 2020).

4.3. Case vignettes on withholding or reallocating care

Below the surface, case B1–B3 poses the dilemma of whether the life saved would be more worthy than the death averted. Rather than a simple numeric comparison of expected outcome, this dilemma requires a judgement of value and preference. Such an assessment is always incomplete and will inevitably suffer from incomplete information, bias and practice variation (Van Essen et al., 2017). Overall outcome after hemorrhagic stroke or severe traumatic brain injury is generally poor. Yet, exact prognostication is uncertain and the benefit of treatment is not guaranteed. (Kelly et al., 2013).

Cases C1 to C3 pertain to the reallocation of a scarce vital resource. This decision can be informed by the prognosis of patients estimated using the data provided in the description. Mortality risk at day 14 amounts to 8.9% (95%CI 6–13) and 12.1% (95%CI 7.8–18.4) for case C1

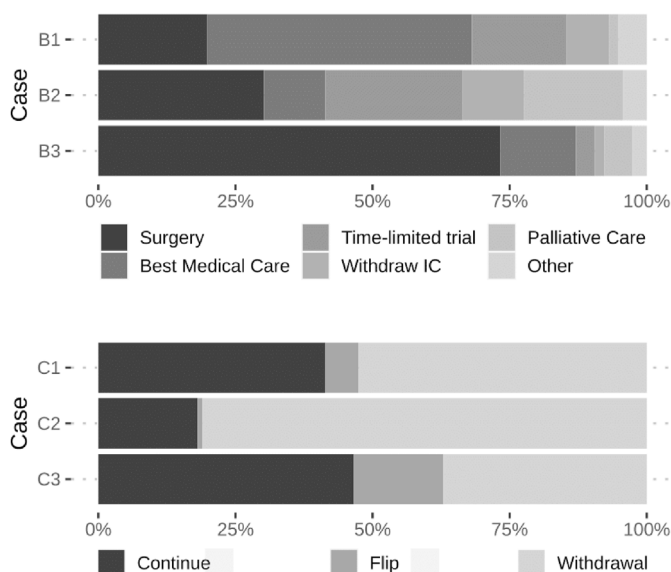


Fig. 2. Top Responses to three cases with acute neurosurgical pathology given the context of very few ICU beds available.

Case B1: 61yo M, right hemiplegia and aphasia since 5 h, GCS 12/15 - left-sided intracerebral hematoma at internal capsule (40 mL) and intraventricular blood. Comorbidities: hypertension, diabetes and moderate chronic renal failure.

Case B2: 81yo M, living independently, right hemiplegia and speech difficulties since a few hours, GCS 14/15 - left frontal lobar hematoma (25 mL). Comorbidities: medically managed hypertension. Eight hours later, his clinical status deteriorates progressively and GCS becomes 9/15.

Case B3: 45yo F, found with GCS 9/15, pupils equal and reactive, withdraws on pain at the left side, no motor response on the right side - diffuse subarachnoid haemorrhage (Fisher grade 3), ruptured aneurysm anterior communicating artery managed with external ventricular drain and coiling. Day 10 - ICP levels spike despite drainage, sedation and osmotic therapy. CT shows new hypoattenuation and swelling in the territory of the right MCA.

Bottom Responses regarding withdrawal of invasive ventilation in favour of another patient given a context of demand for acute care exceeding capacity. (35-year-old mother of two, admitted earlier today for respiratory distress with confirmed COVID-19, necessitating intubation and requiring mechanical ventilation. Her chances of functional recovery with intensive care are estimated as “good”, implying a mortality of less than 33%)

Case C1: 70yo F, independent at home, admitted the previous day after she fell down some stairs. Clinical exam at admission: GCS 13/15, localizing to pain, both pupils reactive. Urgent craniotomy for left-sided acute subdural hematoma (thickness of 15 mm and midlineshift of 7 mm) and slight parenchymal contusion temporal. Postoperative scan was good. Weaning from the ventilator is not yet possible due to respiratory reasons.

Case C2: 25yo M, bicycle crash 2 weeks ago. Cardiac arrest, received bystander CPR. Workup - subaxial cervical fracture with medullary ischemia C4 to C6. Cerebral MRI shows mild hypoxic-ischemic injury. Actual exam - comatose patient, mechanical ventilation, pupils miotic and reactive, preserved corneal and oculovestibular reflexes. No motor response. Flaccid limbs. No plantar reflexes. MEPs of the median nerve absent.

Case C3: 35yo mother of one, day 8 after motor vehicle accident. At admission unresponsive, intubated, flexes on pain bilaterally, pupils reactive. Initial CT scan showed diffuse cerebral edema with obliteration of the basal cisterns, no mass lesion. Unilateral pneumothorax managed by thoracic drain. External ventricular drain. ICP-guided sedation and osmotic therapy. Her ICP levels are stabilising and a clinical exam during temporary wake-up shows a withdrawal to pain instead of the flexion posturing present previously.

and C3 respectively according to the MRC CRASH prognostic model (The MRC CRASH Trial Collaborators, 2008). Risk of unfavourable outcome (dead, vegetative state or severe disability as defined by the Glasgow Outcome Scale) at six months is estimated as 43.2% (95%CI 35.5–51.2) and 35.4% (95%CI 26.2–45.9), respectively according to the same model. The estimate of six months mortality risk is 29% and 33%, respectively according to the TBI-IMPACT Core + CT prognostic model

Table 3

Qualitative analysis of open-ended questions as to what had influenced the respondent's choice of answer for cases C1–C3. The specific topics are ranked by the frequency that they were mentioned. The same respondent could have answered in more than one category.

Considerations in judgment	N° of mentions
Neurologic/function outcome	45
Age	39
Expected outcome/prognosis	33
Survival/mortality	15
Quality of life	10
First come, first served	9
Withdrawing unacceptable/more difficult than not starting	8
Premorbid condition/life expectancy	7
First do no harm	3
<u>Additional information that could alter opinion</u>	
Advanced Care Directives	9
Discussion with relatives	9
Available beds in hospital	5
Multidisciplinary discussion	3
Other imaging studies	3
Scoring systems (SOFA score or other)	2

(Steyerberg et al., 2008). One should note that both the CRASH model and IMPACT model are validated only for outcomes in patients with severe or moderate traumatic brain injury. A conservative estimate for case C2 (ventilator-dependent spinal cord injury with traumatic cardiac arrest) would be a 1-year mortality risk of 75% (DeVivo and Ivie, 1995).

Given the similar mortality rates for the cases C1 and C3 when compared to the reference COVID-19 case (35-year old female, expected good functional recovery with intensive care, mortality less than 33%), the *most ethical* attitude might be to randomly allocate ventilators. Although it is not our intention to promulgate “the right” answer, we do discuss the ethical considerations in more detail below.

4.4. Influencing factors and ethical frameworks

Remarkably, we found the number of neurosurgeons in the same practice to be a significant influencer in multiple cases. This may reflect pre-existing practice variation or could be the result of the fact that larger, mostly academic, centres, experienced a relatively higher load of COVID-19 cases in comparison with smaller centres (Mathiesen et al., 2020).

Cases C1 to C3 pertain to a situation where continuing the ventilator in the neurosurgical patient inevitably results in the death of the COVID-patient and vice versa. It follows that in the end, the result is the same: one patient dies, and the other patient is given a chance to survive, albeit with an uncertain functional outcome. Therefore, both choices can be considered equivalent under a framework of preserving life (Emanuel et al., 2020).

Based on the qualitative analysis of the answers to the open question (see Table 3, Influencing factors for reallocation of the ventilator) we can theorize the ethical frameworks that are considered. No single universal ethical principle adhered to by all respondents could be identified.

Recurrent themes were age and expected outcome, suggesting a desire to maximise benefit (QALY gained) and adherence to a utilitarian framework. Such a strategy is highly dependent on the ability to accurately estimate prognosis (Hulsbergen et al., 2020). Yet, very few respondents specifically mentioned the estimation of outcome with prognostic tools.

In contrast, a sizable proportion of respondents deemed it universally unacceptable to withdraw treatment already started as indicated by answers such as “discontinuing of mechanical ventilation unacceptable” and “First do no harm”, suggestive of a deontological or care-based ethic. This approach essentially boils down to a first-come, first-served principle which seems to uphold the ethic of providing equal opportunity to each, i.e. egalitarianism, at first sight. Conversely, as intensive care constitutes an urgent need, “first-come, first-served” would unfairly

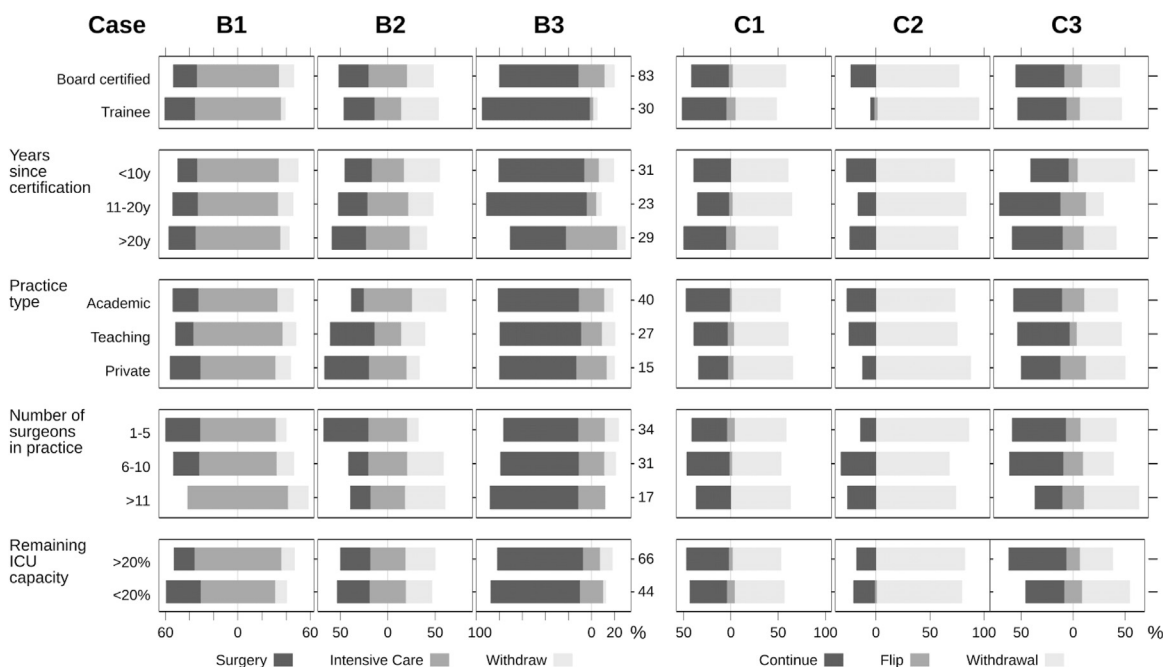


Fig. 3. Influence of career status, remaining ICU capacity for non-COVID cases, practice type (board certified only) and practice size (board certified only) on the likelihood of respondents to opt for withdrawal of intensive care. See caption of Fig. 2 for a description of the cases.

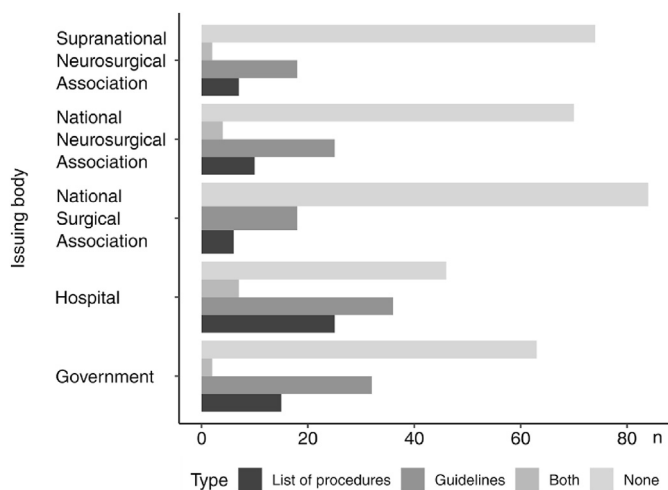


Fig. 4. Counts of what type of guidelines regarding postponement of elective surgeries respondents received and by what kind of body they had been issued.

benefit patients already admitted to the ICU and deprive people who happen to get to the hospital later, regardless of their respective expected outcome. Therefore, it could be argued that random allocation is the most egalitarian approach (Emanuel et al., 2020; Hulsbergen et al., 2020).

The design of the present survey precludes us to make more definitive statements as to what are the guiding principles behind the *average neurosurgeon's* decision-making process with regard to the discontinuation of treatment.

4.5. Limitations of the study

As this study was voluntary and accessible online, we had no explicit control over who took the survey and thus our group of respondents may not necessarily represent the opinion of all neurosurgeons. We did not examine the influence of culture or religion on ethical decision-making. The survey reached relatively few participants outside of Europe and

Australia. However, there was a good mix of early, mid and late-career neurosurgeons, as well as trainees.

Though care was taken to phrase the questions in the most unambiguous way, we cannot verify that every participant understood the scenario as intended. We did not include specific radiological images to accompany the case description out of fear this could influence opinions haphazardly. Rather, we provided exact measures that can be related to those found guidelines (e.g. volume of intracerebral hematoma). Unavoidably, our textual description foregoes the information gained by clinical examination of a patient.

Also, these hypothetical cases may not necessarily represent those that all respondents encounter within the scope of their daily practice. We intentionally did not include cases that are clearly urgent and essential (e.g. cauda equina syndrome) or, vice versa, non-urgent and not-essential. Instead, we focused on cases in the grey area in between.

5. Conclusions

The ongoing COVID-19 pandemic has a significant impact on healthcare worldwide. The continued demand on healthcare requires hospitals, and by extension neurosurgeons, to focus on preserving resources. Despite tremendous efforts to preserve resources and imposed limitations on elective surgical procedures, considering withholding or withdrawing treatment - although difficult and controversial - has become inescapable. Notwithstanding the limitations of empirical evidence gathered from surveys, we believe that our study is relevant in the field of applied Neuro-ethics and Neurosurgery as a whole. To the best of our knowledge, this is the only survey of neurosurgeons on management during the pandemic going beyond mere urgency assignment. We are convinced that knowledge of ethical principles and contemplation of case vignettes help singular care provider teams make decisions on a more just basis, benefiting both the patients under their care and society as a whole.

The neurosurgical community should strive to establish a minimal common base of ethical guidelines and principles to be applied during a future public health crisis. As a result of our culturally diverse society, such guidelines will inevitably be more general on the supranational level, yet increasingly specific on the regional level.

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Informed consent

For this type of study, a voluntary questionnaire, formal consent is not required. Informed consent was considered implicit on submitting the survey answers.

Declaration of competing interest

All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.bas.2022.100925>.

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