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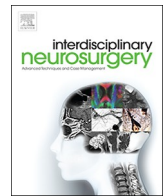
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Research Article

The neurosurgical curriculum: Which procedures are essential?

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A B S T R A C T

Objective: Traditionally, neurosurgery is a competitive field. Throughout the years, the surgical armamentarium has been subject to change, e.g. due to the rise of indications for gamma knife, functional or endovascular surgery. Furthermore, due to modern day issues among residents, such as work hour restrictions (WHRs) and prevalence of burn-out, may require contemporary modifications of the neurosurgical curriculum. By the means of this cross sectional research, the current curriculum is evaluated.

Methods: In September 2019, a 21-question survey was mailed to members of the Congress of Neurological Surgeons using SurveyMonkey. The survey consisted out of 3 parts: demographics of the respondents, respondent's neurosurgical residency and opinions on essential procedures.

Results: After the two reminders, 578 members responded resulting in a response rate of 7.3%. Respondents had a mean residency program of 7 years (range 3 to 12 years). Of the residents, 87.5% had a weekly WHR of 80 h per week. A minority (43.8%) felt WHRs would limit the chances of residents to master surgical techniques.

Neurotraumata procedures such as decompression of subdural (91.5%) and epidural (91.3%) hematoma's, ventriculoperitoneal shunt insertion (86.9%), Chiari decompression (81.4%) and cervical discectomy (81.4%) were the procedures respondents mastered the most. This in contrast to endovascular procedures (67.9%), percutaneous endoscopic lumbar discectomy (48.5%) and deep brain stimulation (34%), in which respondents were less proficient.

Conclusions: The current study gives an evaluation of different neurosurgical curricula and aimed to identify which surgical procedures are deemed as essential by neurosurgeons worldwide. Functional neurosurgery is the field in which most neurosurgeons required more instruction. Neuroendovascular and Gamma knife surgery were subspecializations in which neurosurgeons were less proficient but also specializations that were deemed more desirable to be known during residency.

1. Introduction

With 71.5% of the applicants successfully matching into neurosurgery during 1990–2007, the neurosurgical specialty is one of the most competitive specializations [1]. Historically, the surgical residency program can find its roots in the format introduced by dr. William Halsted, who strived for a structured training program to raise competent surgeons [2,3]. Throughout the years, modifications have been made to this model and neurosurgical curricula may differ between countries and between institutions. In the U.S. and in many European countries, the residency concludes with a board examination in which theoretical knowledge and clinical management are tested among others.

As all education is dynamic, the neurosurgical curriculum is dynamic too. On one side, surgical indications are changing [4]. Examples of this is the decrease in the need for cervical fusion procedures in patients with rheumatoid arthritis due to the introduction of disease-modifying anti-rheumatic medications and biologicals or the broadening of the indications for Gamma knife surgery [5,6].

On the other hand, the educational environment is changing. Due to technological advances in virtual reality, there seems to be an increasing role of surgical simulators in surgical training programmes [7]. Furthermore, there is a growing attention for the physical and mental well-being of today's and tomorrow's physicians. A recent study among neurosurgeons showed that 73.6% of the neurosurgeons experienced work-related musculoskeletal injury, and that 14.2% considered changing their career because of this [8]. Another study drew attention to the fact that among 346 U.S. neurosurgery residents, the burnout rate was 67%. A notable factor associated with this was an inadequate operating room exposure [9]. Due to all these changes, the neurosurgical curriculum may require modifications to fit into the modern day era.

Because of the dynamics that might be expected in resident training programs and because of possible international differences in training programs, an evaluation of neurosurgical curricula seems appropriate. More than a decade ago, a survey among 223 young neurosurgeons showed that in general, training in neurosurgery was judged as adequate but that training in six areas were inadequate: endovascular surgery, treatment of pain, epilepsy surgery, cranial base surgery and

Abbreviations: CNS, Congress of neurological surgeons; WHR, Work hour restriction

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Table 1
Baseline characteristics of the 579 respondents. Answers were divided between neurosurgeons and neurosurgery residents.

	Neurosurgeon(N = 475, 82.0%)	Resident(N = 104, 18.0%)	p-value
Gender	475	104	p = 0.002
Male	423 (89.1%)	81 (77.9%)	
Female	52 (10.9%)	23 (22.1%)	
Tenure	475	104	p < 0.001
1–2 yrs	22 (4.6%)	12 (11.5%)	
3–5 yrs	37 (7.8%)	55 (52.9%)	
6–10 yrs	59 (12.4%)	35 (33.7%)	
> 10 yrs	357 (75.2%)	2 (1.9%)	
Employment	463	103	p = 0.004
Full time	405 (87.5%)	101 (98.1%)	
Part time	58 (12.5%)	2 (1.9%)	
Continent	475	104	p = 0.010
Africa	6 (1.3%)	4 (3.8%)	
Asia	37 (7.8%)	1 (1.0%)	
Europe	27 (5.7%)	4 (3.8%)	
North America	378 (79.6%)	94 (90.4%)	
Oceania	7 (1.5%)	0	
South America	20 (4.2%)	1 (1.0%)	

stereotaxic radio- and neurosurgery [10]. In this study, neurosurgeons and neurosurgery residents were surveyed to evaluate the current neurosurgical curriculum and to determine which surgical procedures are deemed essential for neurosurgeons.

2. Methods

Based on the literature and discussion between a researcher, a neurosurgeon and a resident in neurosurgery, a first draft of the survey was made [11,12]. The survey consisted out of 3 parts:

2.1. Demographics of the respondents

This included questions regarding gender, tenure, employment type and working location.

2.2. Own neurosurgical residency

This included questions regarding the length of the residency program, opinions on consequences of work hour restrictions (WHRs), conducting a fellowship and competence in the different subspecializations of neurosurgery. Furthermore, respondents were asked to rank their competence in 24 different surgical procedures from different neurosurgical subspecializations.

2.3. Essential procedures

All respondents were asked to name 5 procedures that all neurosurgeons must master after residency and 3 procedures they wish they would have mastered during their residency. Furthermore, respondents were asked to rank the desirability of mastering the same 24 surgical techniques of the previous section.

An online survey was emailed to members of the Congress of Neurological Surgeons (CNS) in September 2019 using SurveyMonkey. The CNS is an international professional organization founded to improve neurosurgical care. The email contained an invitation letter with a link to the survey. The survey contained 21 questions. To increase response rate, two reminders were sent over the month September and October 2019. By filling out the survey the respondent gave informed consent. Only surveys filled in by neurosurgeons and neurosurgical residents were included. The need of Institutional Review Board approval was waived because no patients were involved in this study.

The Statistical Package for Social Sciences (version 21.0) was used for analysis of data. Chi-squared tests were used to compare categorical data. A p-value < 0.05 was considered to be statistically significant.

3. Results

Inquiry of the CNS-member directory, resulted in 9007 members. Of these, 8457 had an e-mail address available of which 7932 were functional. After the two reminders, 578 members responded resulting in a response rate of 7.3%.

3.1. Demographics

Table 1 gives an overview of the respondents' demographics. 82% of the responders were neurosurgeons while 18% were neurosurgical residents. Residents were more likely to be female than neurosurgeons (22.1% vs. 10.9%, p = 0.002). Regarding employment type, 12.5% of the neurosurgeons worked part-time, in comparison to 1.9% of the residents (p = 0.004). Fig. 1 gives a demographical overview of the respondents' working locations. The majority of the responders were from North America (81.5%), followed by Asia (6.6%), Europe (5.4%) and South America (3.6%). Africa (1.7%) and Oceania (1.2%) were less represented.

3.2. Neurosurgical residency

Respondents had a mean residency program of 7 years (range 3 to 12 years). Of the residents, 87.5% had a weekly WHR of 80 h per week. When asked if respondents felt if WHRs would limit the chances of residents to master surgical techniques, the opinions were divided. Majority (56.2%) answered no. The mean age when finishing neurosurgical residency was 33.3 years (± SD 2.9). 57.3% of the

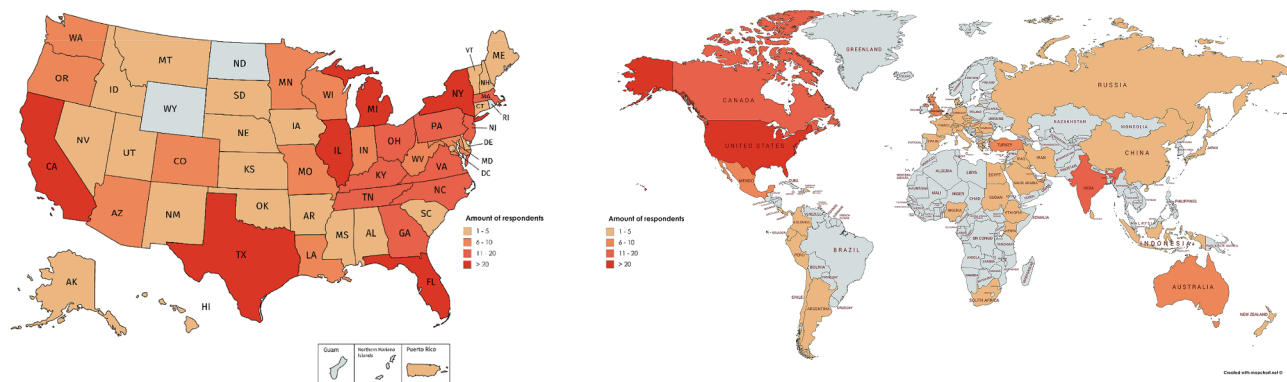


Fig. 1.

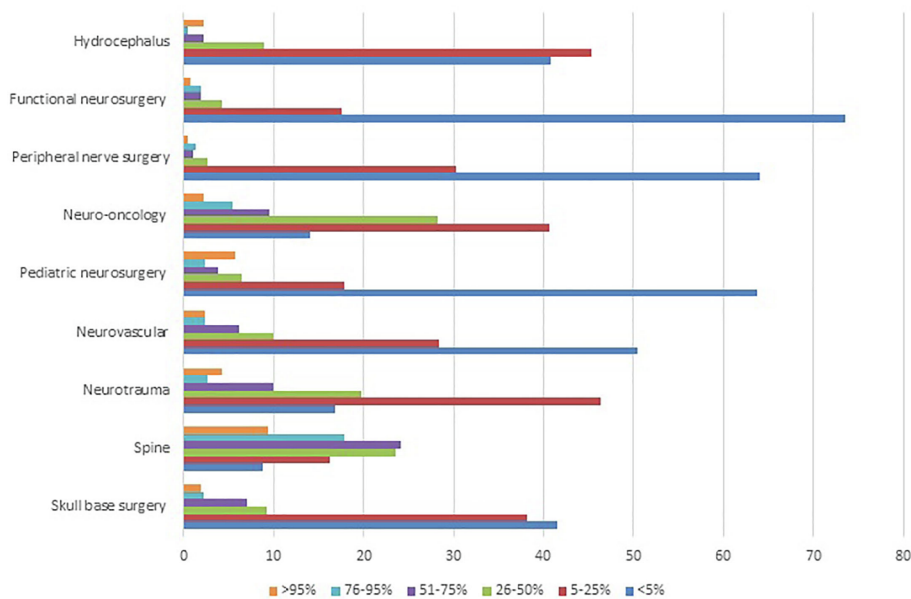


Fig. 2.

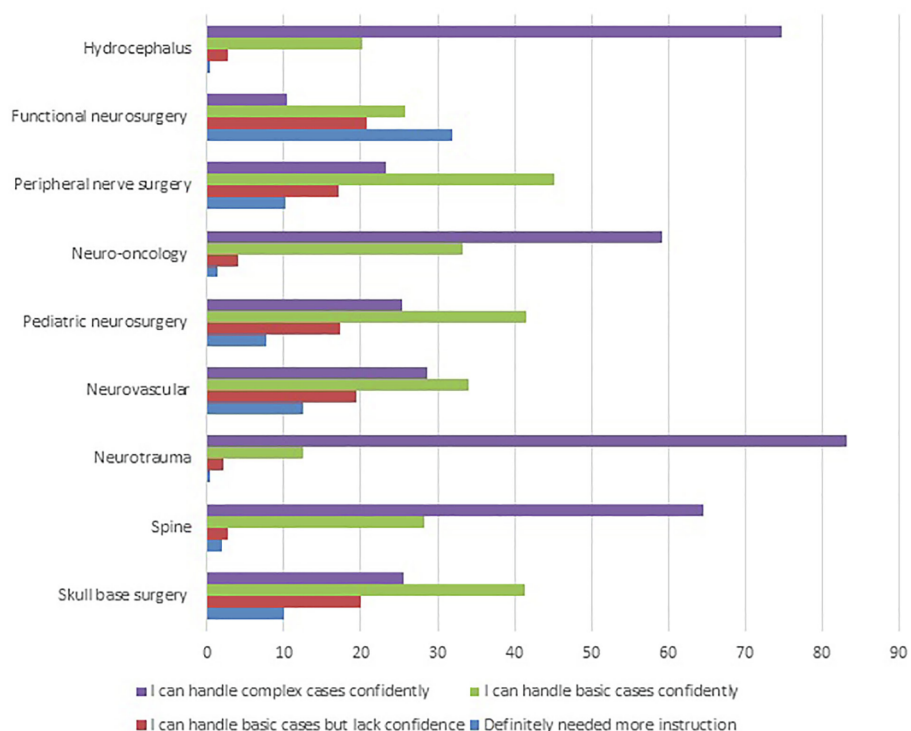


Fig. 3.

neurosurgeons conducted a fellowship after residency. Most followed fellowships were pediatrics, spine, skull base and vascular neurosurgery. Fig. 2 gives an overview of the importance of different sub specializations in daily practice among respondents. Spine, neurotrauma and neuro-oncology were the most frequently practiced, while functional neurosurgery, peripheral nerve surgery and pediatric neurosurgery were less practiced. When asked on own capability of handling cases from different neurosurgical sub specializations, complex cases of neurotrauma, hydrocephalus, spine and neuro-oncology could be handled by 83.2%, 74.8%, 64.5% and 59.2% respectively (see Fig. 3). Functional neurosurgery was the discipline in which most respondents

needed more instruction (31.9%), with 10.4% stating to be able to handle complex cases confidently.

Fig. 4 gives an overview of respondents own competence regarding 24 procedures from different neurosurgical subspecializations. Neurotraumatological procedures such as decompression of subdural (91.5%) and epidural (91.3%) hematoma's, ventriculoperitoneal shunt insertion (86.9%), Chiari decompression (81.4%) and cervical discectomy (81.4%) were the procedures respondents mastered the most. This in contrast to endovascular procedures (67.9%), percutaneous endoscopic lumbar discectomy (48.5%) and deep brain stimulation (34%), in which respondents were less proficient.

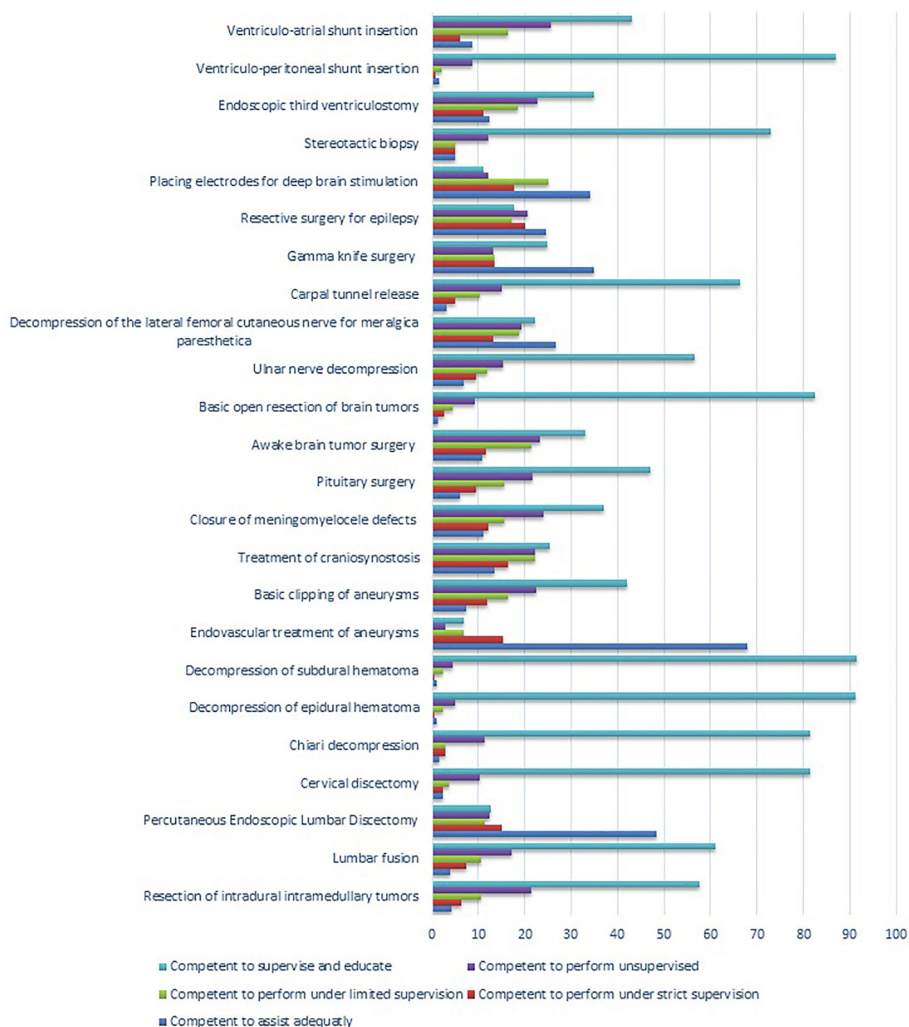


Fig. 4.

Table 2
essential procedures.

Answer	Answer
Top procedures neurosurgeons should master	Procedures respondents think they should have mastered during residency
1 Decompressive craniotomy	1 Spinal fusion
2 Lumbar discectomy	2 Vascular neurosurgery
3 CSF shunting	3 Functional neurosurgery
4 Cervical discectomy	4 Endovascular surgery
5 Cervical/ lumbar laminectomy	5 Skull base surgery

3.3. Essential procedures

Table 2 gives an overview on essential procedures mentioned by respondents. When asked which 5 procedures all neurosurgeons should master decompressive craniotomy for neurotrauma was mentioned the most, followed by lumbar discectomy and shunting of cerebrospinal fluid. When asked which procedures they wanted to have learned during residency, but did not learn, spinal fusion was mentioned the most. Vascular, functional and endovascular neurosurgery followed in frequency.

When respondents were asked to indicate the importance of mastering the same 24 procedures from Fig. 4. Decompressive craniotomy for neurotrauma (99.7%), VP-shunt insertion (96.5%), basic neuro-

oncological resections (95.5%) and cervical discectomy (94.4%) were mentioned as ‘must know’(see Fig. 5). Deep brain stimulation (39.7%), percutaneous endoscopic lumbar discectomy (35.3%) and decompression of the lateral femoral cutaneous nerve (33.7%) were deemed as procedures that were not important to be known after residency.

4. Discussion

4.1. Summary

The present study aimed to evaluate the neurosurgical curriculum and to identify opinions on mastering various surgical techniques from different neurosurgical subspecializations. 578 members of the CNS, of which 475 neurosurgeons, filled in a survey. Most respondents had WHRs. Of the different subspecializations, functional, vascular and peripheral nerve surgery were specializations in which respondents were the least proficient. This in contrast to neurotrauma, hydrocephalus treatment and spine surgery. When comparing the desirability to know one of the procedures, against own competence to perform the procedure, peripheral nerve procedures such as ulnaris and lateral femoral cutaneous nerve decompression are more mastered than respondents deem it important to be mastered. Furthermore, the emerging role of mastering the endovascular treatment of aneurysms is underlined with 67.4% of the respondents indicating that it is ‘desirable’ or ‘good to know’, while 67.9% is only able to assist during the procedure.

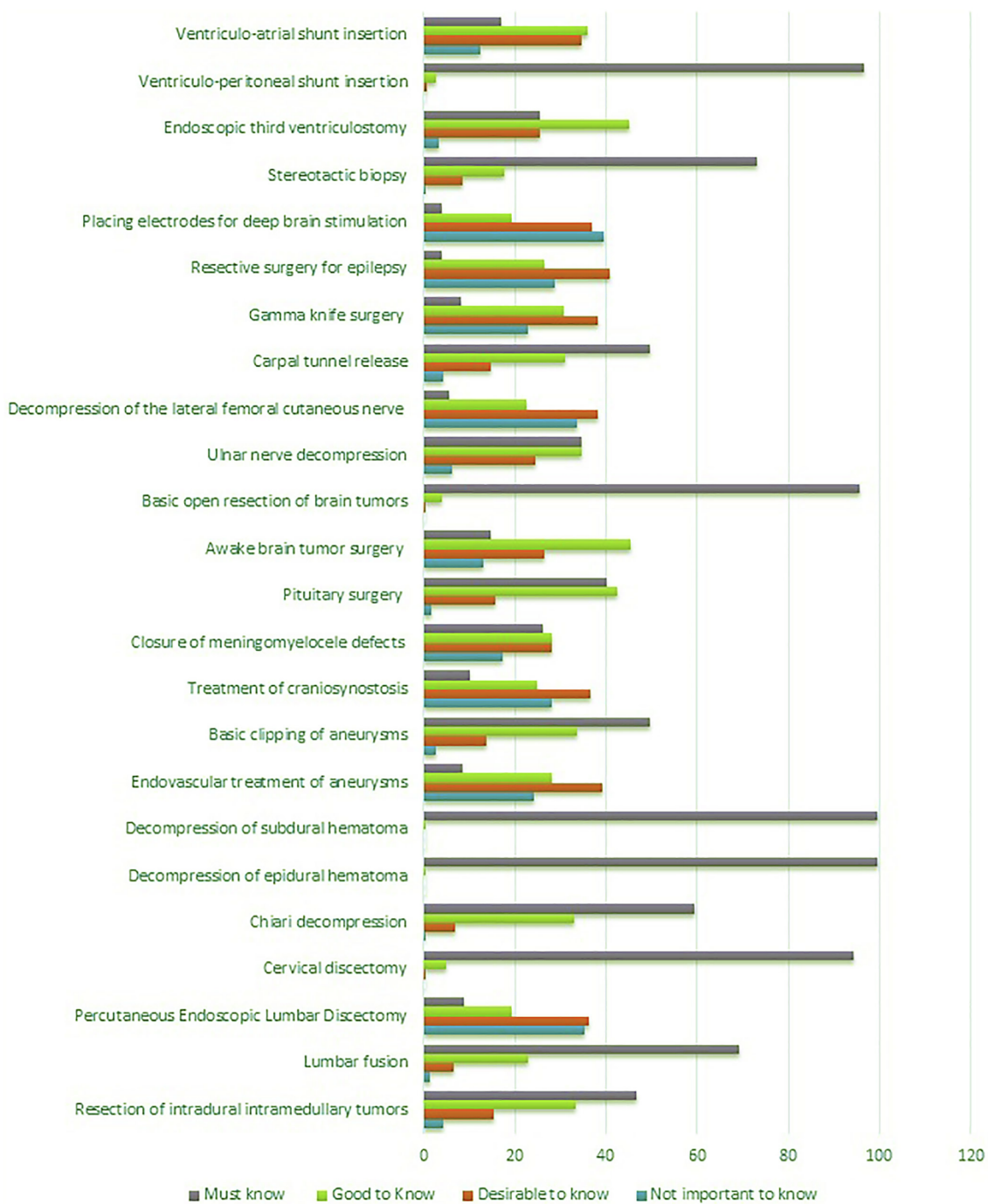


Fig. 5.

4.2. Comparison with literature

In 2003 and 2011, WHRs were implemented to improve the work-life balance of residents, ultimately to also improve patient safety. After the implementation of WHRs, there was a strong decline in the surgical case load residents from Europe had [13]. In 2016 Bina et al. published a literature review on the effects of WHRs on resident fatigue, training and patient safety in both neurosurgical and non-neurosurgical fields [14]. In some specializations such as intensive care and military medicine, WHRs have had positive impacts on safety and fatigue. In the neurosurgical setting however, mostly negative impacts have been reported such as an increase in postoperative complications and a decreased productivity from neurosurgery residents. This conflicting

evidence on benefits of WHRs between specialties, is also shown in this survey where residents were divided on the effect of this on their surgical exposure.

Opinions on Gamma knife surgery were diverse with 22.8% deeming it not important to be known by neurosurgeons and 68.9% deeming it ‘desirable or good to know’. Furthermore, 35% was competent to only assist procedures, while 27% was able to perform Gamma knife surgery under supervision and 38% was competent to perform it unsupervised. The position of Gamma knife surgery and stereotactic radiosurgery in the neurosurgical curriculum has been studied previously [6]. In a mixed-methods study among Canadian neurosurgical program directors were asked to share their opinions on resident exposure to stereotactic radiosurgery, the desirability of neurosurgeons

having knowledge on radiosurgery, the collaboration with radiation oncologists and methods to improve residents' exposure to radiosurgery. Almost all program directors acknowledged a low exposure to radiosurgery at their institution and thought that although exposure is variable per institution, the overall exposure is insufficient. Furthermore, all program directors indicated that neurosurgeons should have basic knowledge of radiosurgery treatment, without the necessity to apply radiosurgery. Three strategies were named to improve resident exposure which were involving residents in tumour boards, an internship in radiosurgery and adding radiosurgery to the training requirement at national level.

Just like with Gamma knife surgery, the possible applications of endovascular surgery to treat neurosurgical pathology is also on a rise. In some countries as the U.S., vascular neurosurgeons are trained both in open vascular and neuroendovascular procedures. This in contrast to some European countries in which the total of independently performed, supervised or assisted endovascular procedure is nihil [13], probably due to endovascular procedures not being incorporated into curricula. In the current study, only 6.8% of the surveyed neurosurgeons, deemed themselves competent enough to supervise and perform endovascular procedures independently, while 24.1% don't deem it important enough to be known among residents. These results are highlighted by a 2013 study among neuroendovascular fellowship program directors [4]. The results show that despite good demonstrated professionalism, communication/clinical skills and interest in research, 50% of the fellows were unable to formulate an appropriate treatment plan. Furthermore, 79% were unfamiliar with endovascular devices, while 75% were unfamiliar with angiographic equipment, emphasizing a competence gap between residents and fellows regarding neuroendovascular training.

4.3. Strengths and limitations

The main strength of this study is that 578 neurosurgeons and residents were surveyed from all continents on the importance of different surgical procedures. Some limitations have to be acknowledged. One is the response rate of 7.3%. As it is customary, multiple reminders were sent to increase the response rate. The response rate of this study is comparable to other contemporary surveys among CNS or American Association of Neurological Surgeons with response rates from 4.9% to 15.8% [8,15–17]. Furthermore, no demographic data was available of non-respondents so generalizability of the data of the 7.3% respondents could not be assessed. Another limitation may be caused by local agreements within clinics. For instance, in some clinics plastic surgeons perform peripheral nerve surgery, while in others lumbar fusion is performed by orthopedic surgeons. These agreements can make it difficult for respondents to rate the importance of mastering these techniques if they are performed by other disciplines locally. Despite these limitations, enough responses were received to elucidate the current opinions on mastering certain neurosurgical procedures.

5. Conclusions

The current study gives an evaluation of different neurosurgical curricula and aimed to identify which surgical procedures are deemed as essential by neurosurgeons worldwide. In all neurosurgical subspecializations one or more procedures were deemed to be essential.

Functional neurosurgery is the field in which most neurosurgeons required more instruction. Neuroendovascular and Gamma knife surgery were subspecializations in which neurosurgeons were less proficient but were deemed more desirable to be known.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.inat.2020.100723>.

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