Professional Profiles, Technical Preferences, Surgical Opinions, and Management of Clinical Scenarios from a Panel of 63 International Experts in the Field of Chiari I Malformation

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■ BACKGROUND: **Chiari I Malformation (CMI) and the topics concerning it have been the subject of numerous discussions and polarizing controversies over the course of the past 20 years.**

■ METHODS: **The opinions of 63 recognized international Neurosurgical CMI experts from 4 continents, with a collective surgical experience of more than 15,000 CMI cases, were gathered through a detailed questionnaire, divided in two parts: diagnostic and therapeutic.**

The therapeutic part was organized into four sections: Professional Profile, Technical Preferences, Surgical Opinions, and Clinical Scenarios.

■ RESULTS: **The data reflected a wide spectrum of opinions, approaches, and expertise.**

The second part of the questionnaire dealt with the surgical aspects of CMI care and painted a more complex picture:

- **81% of the surgeons preferred the Intradural technique.**
- **88% of the experts agreed that CMI surgery is not indicated for minimal non-debilitating symptoms alone, or as prophylaxis.**
- **In the face of given clinical scenarios, a wide spectrum of therapeutic approaches was chosen by the whole group, but the 4 Surgeons with the largest case series expressed the same opinion.**
- **Eight out of 63 Surgeons had a surgical experience above 600 cases, were responsible for more than half of the total 15,000 declared CMI cases, and shared a similar profile in terms of technical surgical choices, therapeutic opinions, and low complication rate, with a marked preference for Intradural techniques and tonsillar manipulation.**
- **Once large individual case series were accumulated, we did not see any differences in the opinions and preferences between Adult and Pediatric Neurosurgeons.**

■ CONCLUSION: **Surgeons who have focused on CMI have been able to accumulate large surgical series, have chosen in their practices the more aggressive (and intrinsically more effective) CMI surgical techniques, and have achieved a low complication rate which compares favorably with that one of the extradural techniques.**

INTRODUCTION

Chiari I malformation (CMI) and the topics concerning it have been the subject of numerous discussions and polarizing controversies over the course of the last 20 years.[1-4]

To get a clearer idea of current opinions among clinicians focused on CMI management, we decided to poll a number of experts in that field, to gather information relative to their opinions and their experience.

MATERIALS AND METHODS

We contacted 100 clinicians with a recognized interest in CMI from 4 continents to answer an ad hoc questionnaire, as a preface to the XXIX Conference of the American Chiari and Syringomyelia Alliance Project, which took place in Long Island, New York, on July 19–23, 2017. These clinicians were identified from a PubMed search of authors of Chiari-related publications over the last 20 years. We received replies from a total of 63 CMI experts, with a collective surgical experience of more than 15,000 CMI cases.

Key words
- Chiari I malformation
- Questionnaire
- Syringomyelia

Abbreviations and Acronyms
CMI: Chiari I malformation
CSF: Cerebrospinal fluid
SM: Syringomyelia

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The 63 responders to the questionnaire hailed from 4 continents and had a collective reported surgical experience well in excess of 15,000 CMI cases, with 8 surgeons being responsible for more than half of those cases. The number 15,000 represents a conservative estimate. Five of the responders opted to enter their replies anonymously and to skip the questions of the professional profile. In addition to them, 6 other surgeons in the poll (some of whom are known to be high-volume CMI surgeons) opted not to answer the question about the size of their past CMI surgical experience. Some of the responders did not answer some of the clinical questions.

The list of identified poll participants along with their respective declared surgical volume is shown in Table 1.

The questionnaire contained 90 items and was administered through the Survey Monkey platform (SVMK, San Mateo, California, USA). The results of the questionnaire underwent basic descriptive statistical analysis on Microsoft Excel for Mac, Version 16.19 (Microsoft, Redmond, Washington, USA).

The first part of the questionnaire (questions 1–51) focused on pathophysiology, epidemiology, symptomatology, and comorbidities of CMI. Its results were published earlier in this journal.[5]

This article will focus on the analysis of the results of the second part of the questionnaire (questions 52–90, with multiple choice format), which covered topics related to professional profiles, technical preferences, surgical opinions, and clinical scenarios.

RESULTS

The list of the questions is presented in Tables 2–5. Each question was identified by its progressive number in the questionnaire. The questions are arranged in numerical order and grouped by topic, along with the polling results, as a percentage of the responders: professional profiles (Table 2), technical preferences (Table 3), surgical opinions (Table 4), and clinical scenarios (Table 5).

Fourteen questions scored agreements at 75% or above and have been marked within the tables (questions 55, 58, 60, 63, 64, 65, 67, 69, 71, 76, 79, 80, 81, and 83).

Professional Profiles

Of the clinicians polled, 80% worked in an academic institution (Table 2) and 71% were part of a center focused on the diagnosis and care of CMI and syringomyelia (SM). Most surgeons (70%) spent less than half of their time involved in CMI and SM, whereas 3 were focused full time on these disorders as subspecialty surgeons.

Of all the surgeons, 85% had performed more than 100 Chiari surgeries in their respective careers.

Out of the 63 responders, 8 surgeons had surgical experience above 600 cases and were responsible for more than half of the total 15,000 declared CMI cases. Four of these 8 surgeons had personal surgical case series measuring well above the 1000 mark.

Twenty-six of the 63 polled experts were pediatric neurosurgeons. Two of them had personal surgical series above 900 cases, whereas a third pediatric neurosurgeon had more than 1100 declared CMI surgeries.

Six polled experts decided to remain anonymous.

Declared complication rates (of pseudomeningocele and cerebrospinal fluid [CSF] fistula) varied from more than 50% for 3 surgeons to less than 1% for 23 surgeons (42%). The 3 surgeons with the highest declared surgical volume (one of whom was a pediatric neurosurgeon) had a complication rate of less than 1%, despite the fact that all of them opened both the dura and the arachnoid as part of their practice.

The number of articles about CMI and SM published ranged from less than 10 for 35 surgeons (62.50%) to more than 100 for 2 participants.

Of the clinicians, 73% polled ran or participated in institutional review board or other research studies focused on CMI and/or SM.

Technical Preferences

Of the responders, 18.5% favored an extradural technique for the Chiari decompressive surgery (Table 3). Most of the surgeons (81%) opted for the intradural technique and were almost evenly split between being in favor or not being in favor of tonsillar reduction as an adjunct intradural maneuver. Whenever the dura had to be opened, 75% of the surgeons entered the arachnoid as well.

Most of the polled experts chose a medium-sized craniectomy ranging between 2.5 and 5 cm^2 (64%), and always performed a C1 laminectomy (76%).

The choices of the duraplasty materials included bovine patches (35%), autologous pericranium (32%),[6] synthetic materials such as Gore-Tex (12.5%), autologous fascia (8.9%),[7] and others. Of the surgeons, 4% left the dura open.[8]

A wide spectrum of preferences was also seen in the suturing materials used to secure the duraplasty: polypropylene (39.2%), braided Nylon (30.3%), Gore-Tex (10.7%), and others (19.6%).

Only 5% always used a 4th ventricular stent,[9] whereas 21% used it sometimes. Most surgeons (79%) never used a cranioplasty, whereas 16% used it sometimes.[10,11]

Of the surgeons, 77% routinely used a microscope, whereas 48% used an intraoperative ultrasound during their Chiari decompressive surgeries.[12-14]

When treating idiopathic SM with syrinx shunting, 83% of surgeons did not use a valve,[15,16] and 52% used intraoperative ultrasound as guidance. The distal limb of the shunt was inserted into the subarachnoid space by 65% of surgeons,[17] whereas pleura (27%) and peritoneum (8%) were preferred by others.

Of the pollers, 69% had performed one or more craniocervical fusions on patients with CMI as part of the overall surgical management of specific patients, when indicated.[18]

Surgical Opinions Regarding the Management and Treatment of Patients with CMI

A series of axioms about aspects of the surgical management of CMI were submitted to the pollers (Table 4). The axioms agreed on by most of the polled experts are as follows:

1. Chiari surgery is not indicated for minimal nondebilitating symptoms alone, or as prophylaxis (88%).
2. Extradural CMI decompressive techniques have a lower complication rate than their intradural counterparts (80%).

Table 1. List of the Polled International Chiari Experts

Pediatric Neurosurgeons (n = 26)
Arnold Menezes — University of Iowa, USA*†‡
Jerry Oakes — University of Alabama, USA†‡§
Harold Rekate — Chiari Institute, USA†‡§
Douglas Brockmeyer — University of Utah, USA†‖
Richard Ellenbogen — University of Washington, USA†‖
Neil Feldstein — Columbia University, USA†‖
Lorenzo Genitori — Istituto Meyer, Italy†‖
Timothy George — Dell Children's Hospital, USA†‖
Jeffery Greenfield — Cornell University, USA†‖
Bermans Iskandar — University of Wisconsin, USA†‖
Petra Klinge — Brown University, USA†‖
Tina Loven — Mercy Hospital, USA†‖
Cormac Maher — University of Michigan, USA†‖
Laura Valentini — Istituto Besta, Italy†‖
Jeffrey Wisoff — NYU, USA†‖
Brian Dlouhy — University of Iowa, USA†¶
Ian Heger — MCG, USA†¶
Robert Keating — Washington Children, USA†¶
Jorge Lazareff — UCLA, USA†¶
Vadivelu Sudhakar — Cincinnati Children, USA†¶
Brandon Rocque — University of Alabama, USA†#
Mirko Scagnet — Istituto Meyer, Italy†#
Mark Souweidane — Cornell University, USA†#
Paul Steinbok — BC Children's Hospital, Canada†#
Francesco Mangano — Cincinnati Children, USA†**
Michael Scott — Brigham & Women, USA†**
Adult Neurosurgeons (n = 31)
Yung Liu — Syringomyelia Department, China‡††
Paolo Bolognese — Chiari Neurosurgical Center, USA‡‡‡
Ulrich Batzdorf — UCLA, USA*‡
David Frim — University of Chicago, USA‡§§
John Oro' — Chiari Clinic, USA‡§§
Graham Flint — QE Hospital, UK‖
Gerald Grant — Stanford University, USA‖
Dan Heffez — Chiari Institute of WI, USA‖
Jörg Klekamp — Quakenbrück, Germany‖
David Limbrick — Washington University, USA‖
Sylvia Morar — Hôpital de Bicêtre, Paris, France‖
Misao Nishikawa — University of Osaka, Japan‖
Juan Sahuquillo — University Hospital Vall d'Hebron, Barcelona, Spain‖
Erol Veznedaroglu — Drexler University, USA‖
Nicholas Wetjen — Mayo Clinic, USA‖
Andrew Brodbelt — The Walton Centre, UK¶
John Heiss — NIH, USA¶
John Jane Jr. — MCV, USA¶
Ilzumi Koyanagi — Hokkaido, Japan¶
Antonia Poca — Barcelona, Spain¶
Wouter Schievink — Cedars-Sinai, USA¶
Michael Seiff —The Spine and Brain Institute, Las Vegas, USA¶
Konstantin Slavin — University of Illinois, USA¶
Marcus Stoodley — Macquarie University, Sydney, Australia¶
Kenneth Liu — Penn State, USA#
Yongli Lou — Zhengzhou, China#
Shokei Yamada — Loma Linda University, USA#
Atul Goel — King Edward Memorial Hospital, Mumbai, India**
Mark Luciano — Johns Hopkins, USA**
Fabrice Parker — Hôpital de Bicêtre, Paris, France**
Charles Tator — University of Toronto, Canada**

Within each cohort, the surgeons are listed alphabetically.
CMI, Chiari I malformation.
*Between 1101 and 1300 declared Chiari surgeries.
†Pediatric neurosurgeons and neurosurgeons with a pediatric focus.
‡High-volume surgeons, with a declared surgical volume above 600 CMI cases.
§Between 901 and 1100 declared Chiari surgeries.
‖Between 301 and 600 declared Chiari surgeries.
¶Between 101 and 300 declared Chiari surgeries.
#Less than 100 declared Chiari surgeries.
**Chiari surgical volume not declared.
††More than 1500 declared Chiari surgeries.
‡‡Between 1301 and 1500 declared Chiari surgeries.
§§Between 601 and 900 declared Chiari surgeries.

3. Extradural CMI decompressive techniques have a higher failure rate than their intradural counterparts, and often lead to additional surgeries (77%).
4. Extradural CMI decompressive techniques are less effective than their intradural counterparts (74%).
5. Intradural decompressive techniques complemented by tonsillar reduction have a higher chance of deflating a large SM cavity when compared with their extradural counterparts (71%).

SURGICAL OPINIONS REGARDING THE MANAGEMENT AND TREATMENT OF PATIENTS WITH SM

A series of axioms about aspects of the surgical management of SM were submitted to the pollers (Table 4). The axioms agreed on by most of the polled experts are as follows:

Table 2. Questions and Answers About Professional Profiles

Question	Answer
Question 83: Do you work in an academic institution?	Yes: 80%
	No: 20%
Question 84: How much of your time is devoted to CMI and SM (clinical and research time combined)?	Up to 25% of the time: 45%
	Between 26% and 50%: 25%
	Between 51% and 75%: 15%
	Between 76% and 99%: 11%
	The whole time: 4%
Question 85: How many CMI decompressions and revisions have you performed in your career?	Less than 100: 14.8%
	Between 101 and 300: 29.6%
	Between 301 and 600: 40.7%
	Between 601 and 900: 3.7%
	Between 901 and 1100: 3.7%
	Between 1101 and 1300: 3.7%
	Between 1301 and 1500: 1.85%
	More than 1500: 1.85%
Question 86: If we define both pseudomenigoceles and CSF fistulae as CSF leaks, how do you quantify your overall CSF leakage rate relative to CMI surgeries?	Less than 1%: 42%
	Between 1% and 10%: 44%
	Between 11% and 20%: 9%
	Between 21% and 30%: 0%
	Between 31% and 40%: 0%
	Between 41% and 50%: 0%
	More than 50%: 5%
Question 87: How many articles about CMI and SM have you published in your career (as first author or coauthor)?	Less than 10: 62.5%
	Between 11 and 20: 21%
	Between 21 and 50: 12.5%
	Between 51 and 100: 0.00%
	More than 100: 4%
Question 88: Did you run or participate in IRB or other research studies focused on CMI and/or SM?	Yes: 73%
	No: 27%
Question 90: Are you part of a center focused on the diagnosis and care of CMI and SM?	Yes: 71%
	No: 29%

CMI, Chiari I malformation; SM, syringomyelia; CSF, cerebrospinal fluid; IRB, institutional review board.

1. Aspiration of an SM cavity[19] is an obsolete procedure, fraught with risks and ultimately leading to the spontaneous reinflation of the SM (95%).
2. Whenever an SM needs surgical attention, you treat the cause, then you treat the cause again, and you shunt the SM only as a last resort (93%).
3. Lysis of adhesions complemented by an expansile duraplasty is an acceptable therapeutic modality in cases of SM secondary to dense post-traumatic or postinfective adhesions (89%).[20-22]
4. Terminal ventriculostomy can sometimes help in the management of low thoracic SM cavities (60%).[23]

Clinical Scenarios

A number of different clinical scenarios were presented to the experts to gauge their therapeutic approaches (Table 5). The scenarios in question were simple and linear, and were arranged in a clinical progression.

The responses of the 63 polled experts were spread in quite a wide manner, indicating the lack of a uniform approach to similar scenarios.

Interestingly, when faced with the scenarios described in the questions 73–75, all of the top 4 pollers (by volume of CMI surgeries performed) chose the same option of performing an intradural technique with intradural technique and duraplasty, augmented with tonsillar reduction.

High-Volume Surgeons

The replies of the 8 surgeons with a reported individual surgical experience of more than 600 CMI cases were analyzed separately. The sum of their overall surgical experience accounted for more than half of the total 15,000 declared CMI cases contributed by the entire pool of 63 polled experts.

All of them gave the same answers to a number of key questions, therefore sharing the following surgical profile:

- They believed that Chiari surgery is not indicated for minimal nondebilitating symptoms, or for prophylactic value.
- They used the intradural technique with tonsillar reduction as their default CMI surgery of choice.
- They routinely opened the dura and the arachnoid.
- They had a low incidence of pseudomeningocele.
- They believed that extradural CMI decompressive techniques have a higher failure rate than their intradural counterparts, therefore often leading to additional surgeries.
- With the exception of one of them, they believed that intradural techniques complemented by tonsillar reduction have a higher chance of deflating a large SM cavity than their extradural counterparts.
- They performed surgical revisions of former CMI decompressions, when indicated.
- They performed craniocervical fusions on patients with CMI, when indicated.

DISCUSSION

The results of a questionnaire focused on CMI surgical practices among pediatric neurosurgeons were published in 2004 by Schijman and Steinbok.[24] There were 76 responders, out of 246 pediatric neurosurgeons reached worldwide. A consensus

Table 3. Questions and Answers About Technical Preferences

Question	Answer
Question 52: What posterior fossa decompression technique do currently favor in your clinical practice?	Extradural technique: 18.5%
	Intradural technique without tonsillar reduction: 42.5%
	Intradural technique with tonsillar reduction: 39%
Question 53: What duraplasty material do you currently favor in your clinical practice, when needed?	Autologous pericranium: 32%
	Autologous fascia: 9%
	Cadaveric dura: 2%
	Alloderm: 5%
	Bovine or porcine preparations: 36%
	Synthetic materials: 12%
	I never perform duraplasties: 4%
Question 54: What suturing material do you currently favor in your clinical practice to close the dura?	NUROLON (braided Nylon): 30%
	PROLENE (polypropylene): 39%
	Gore-Tex: 11%
	Other: 20%
Question 55: Do you routinely use the microscope for your Chiari decompressive surgeries?	Yes: 77%
	No: 23%
Question 56: Do you routinely use intraoperative ultrasound during your Chiari decompressive surgeries?	Yes: 48%
	No: 52%
Question 57: How large is your craniectomy during Chiari decompressive surgeries?	Less than 2.5 × 2.5 cm: 34%
	Between 2.5 × 2.5 and 5 × 5 cm: 64%
	More than 5 × 5 cm: 2%
Question 58: Do you routinely perform a C1 laminectomy during your CMI decompressive surgeries?	Yes, always: 76%
	Only if I cannot avoid it: 20.00%
	Never: 4%
Question 60: If you open the dura, do you routinely open the arachnoid as well?	Yes: 75%
	No: 23%
	I never open the dura: 2%
Question 62: Do you use 4th ventricular stenting during your CMI decompressions?	Always: 5%
	Sometimes: 22%
	Never: 73%
Question 63: Do you add a cranioplasty at the end of your CMI decompressions?	Always: 5%
	Sometimes: 16%
	Never: 79%
Question 64: Do you perform surgical revisions of former CMI decompressions?	Always: 5%
	Sometimes: 93%
	Never: 2%
Question 76: If you decide to shunt an essential SM (an SM in which the etiology is elusive and unknown), do you use a valve?	Yes: 17%
	No: 83%
Question 77: If you decide to shunt an essential SM, where do you prefer to insert the distal limb?	Subarachnoid space: 65%
	Peritoneum: 8%
	Pleura: 27%
Question 78: If you decide to shunt an essential SM, do you use intraoperative ultrasound to help you inserting the proximal limb?	Yes: 52%
	No: 48%
Question 89: Have you performed craniocervical fusions (when indicated) on patients with CMI?	Yes: 69%
	No: 31%

CMI, Chiari I malformation; SM, syringomyelia.

was reached about not operating on asymptomatic patients with CMI, unless SM or scoliosis was present. Most of the responders favored intradural techniques, with pericranial or synthetic patches. SM shunting was recommended by most of the pollers, in case of persistent or progressive SM after a Chiari decompression.

More than a decade later, our questionnaire was targeted at 100 neurosurgeons from 4 continents with a recognized interest and expertise in CMI. These clinicians were identified from a PubMed search of authors of Chiari-related publications over the last 20 years. We received replies from a total of 63 CMI experts, with a collective surgical experience of more than 15,000 CMI cases. They were a mix of adult (n = 31) and pediatric neurosurgeons (n = 26). Sic experts did not provide complete information about their own profile.

The results from the first part of the questionnaire (questions 1–51)—which focused on pathophysiology, epidemiology, symptomatology, and comorbidities of CMI—were published in a recent article in this journal.[5] The second part of the questionnaire (questions 52–90, with multiple choice format) covered topics related to professional profiles, technical preferences, surgical opinions, and clinical scenarios.

No questionnaires are perfect, and the current one was no exception. The same questions could have been asked in many other ways. Many other questions could have been asked. Many other topics could have been explored. The structure of the answers could have been different. Only 63 CMI experts replied to our invitation of participating in the questionnaire, out of the 100 we had initially contacted. We are sure that the world experts in the field of CMI are more than 100, and that our list was biased by our direct knowledge of the CMI experts we had repeatedly encountered at dedicated meetings through the years, or read about in the scientific literature we are able to access, with language being a potential source of bias. We do not know how exactly the cohort of the 63 responders ranks in the overall world of the international CMI experts. In addition, a small number of

Table 4. Questions and Answers About Surgical Options

Question	Answer
Question 59: Do you believe in the effectiveness of the dural scoring technique?	I fully agree: 9%
	I agree, but it has limitations: 55%
	I disagree: 36%
Question 61: Intradural techniques complemented by tonsillar reduction have a higher chance of chances of deflating large SM cavity, than their extradural counterparts.	I agree: 71%
	I disagree: 29%
Question 65: Repetition and experience can lead to a reduction of the surgical complication rate in single surgeon series.	I agree: 100%
	I disagree: 0%
Question 66: The involvement of residents can lead to a higher surgical complication rate.	I agree: 39%
	I disagree: 61%
Question 67: Chiari surgery is not indicated for minimal nondebilitating symptoms, or for prophylactic value.	I agree: 87.5%
	I disagree: 12.5%
Question 68: Extradural CMI decompressive techniques are less effective than their intradural counterparts.	I agree: 74%
	I disagree: 26%
Question 69: Extradural CMI decompressive techniques have a lower complication rate than their intradural counterparts.	I agree: 80%
	I disagree: 20%
Question 70: Extradural CMI decompressive techniques have about 65% chances of deflating large SM cavities.	I agree: 50%
	I disagree: 50%
Question 71: Extradural CMI decompressive techniques have a higher failure rate than their intradural counterparts, therefore often leading to additional surgeries.	I agree: 77%
	I disagree: 23%
Question 79: Whenever an SM needs surgical attention, you treat the cause, then you treat the cause again, and you shunt the SM only as a last resort. Do you agree with this axiom?	Yes: 93%
	No: 7%
Question 80: Syringe aspiration of an SM cavity is an obsolete procedure, fraught with risks and ultimately leading to the spontaneous reinflation of the SM. Do you agree with this statement?	Yes: 95%
	No: 5%
Question 81: Lysis of adhesions complemented by an expansile duraplasty is an acceptable therapeutic modality in cases of SM secondary to dense post-traumatic or postinfective adhesions (in the absence of CMI).	I agree: 89%
	I disagree: 11%
Question 82: Terminal ventriculostomy can sometimes help in the management of low thoracic SM cavities.	I agree: 60%
	I disagree: 40%

SM, syringomyelia; CMI, Chiari I malformation.

the 63 responders opted not to answer all the questions. Six of the 63 responders (some with an illustrious international reputation in the field) did not provide information about their declared surgical volume. The declared surgical volumes were not always backed up as published data.

Of the polled experts, 88% in this questionnaire believed that Chiari surgery is not indicated for minimal nondebilitating symptoms alone, or for prophylactic value,[25-27] therefore paralleling the results of the 2004 poll of Schijman and Steinbok.[24]

On one hand, the opinions of these 63 experts have been quite uniform when the surgical treatment of idiopathic SM was discussed.[16,20-22] Conversely, the results of this poll have been widely distributed when the technical points regarding CMI surgery were discussed, therefore reflecting the ongoing diversity of opinions in the recent literature.

Most of the responders in this questionnaire favored intradural techniques (81%). A similar preference was shown in 2004 by the pediatric neurosurgical poll published by Schijman and Steinbok.[24]

The debate about the relative pros and cons of extradural versus intradural decompressive CMI techniques has been ongoing in neurosurgical literature for more than 15 years, and has yet to see an end, despite several articles and metadata analyses.[28-37]

A potential new and original piece of information coming from the experience of this questionnaire in the ongoing CMI surgical debate could reside in the fact that the 8 surgeons with the largest surgical CMI experience among the pollers used the intradural technique with tonsillar reduction as their default CMI surgery of choice. Three of the 8 high-volume surgeons were pediatric neurosurgeons,[7,38] in quite open contrast with the ongoing published trend of many pediatric neurosurgeons favoring extradural CMI techniques.[32,39-41] The 3 surgeons with the highest declared surgical volume among the pollers (2 adult and 1 pediatric surgeons) had a pseudomeningocele rate of less than 1%, despite all them using intradural subarachnoid approaches to CMI surgery.[7,38,42]

The implications of this finding are at the same time both expected and refreshing. On one hand, like has already happened in other neurosurgical subspecialties, frequent repetition often brings technical improvement, increased knowledge of anatomic variants, and a minimization of iatrogenic complications.[43] The growing surgical experience can offer an opportunity to slowly push the surgeon's own limits to higher degrees of technical complexity, within centers focused on CMI, with large numbers of cases per year. On the other hand, with the upcoming model of parallel surgeries and its increased reliance on the involvement of the residents, such process of constant and progressive technical evolution by an individual expert has the potential to be slowed and diluted. In the event of severe

Table 5. Questions and Answers About Clinical Scenarios

Question	Answer
Question 72: You have an asymptomatic patient with CMI and a SM cavity. The SM cavity involves two thirds of the cord length, and more than 75% of the cord diameter at its maximum girth. The neurologic examination is normal. What do you do next?	Clinical observation: 29%
	CMI decompression with extradural technique: 9%
	CMI decompression with intradural technique and duraplasty, without tonsillar reduction: 31%
	CMI decompression with intradural technique and duraplasty, with tonsillar reduction: 31%
	SM shunting: 0%
Question 73: You have a patient with CMI and a large SM cavity. The SM cavity involves two thirds of the cord length, and more than 75% of the cord diameter at its maximum girth. The CMI is heavily symptomatic with debilitating symptoms. The SM is asymptomatic. The neurologic examination is normal. What do you do next?	Clinical observation: 2%
	CMI decompression with extradural technique: 11%
	CMI decompression with intradural technique and duraplasty, without tonsillar reduction: 44%
	CMI decompression with intradural technique and duraplasty, with tonsillar reduction: 43%
	SM shunting: 0%
Question 74: You have a patient with CMI and a large SM cavity. The SM cavity involves two-thirds of the cord length, and more than 75% of the cord diameter at its maximum girth. The CMI is asymptomatic with debilitating symptoms. The SM is symptomatic, with dysesthetic pain, numbness, and moderate weakness. The neurologic examination is abnormal. What do you do next?	Clinical observation: 2%
	CMI decompression with extradural technique: 9%
	CMI decompression with intradural technique and duraplasty, without tonsillar reduction: 40%
	CMI decompression with intradural technique and duraplasty, with tonsillar reduction: 47%
	SM shunting: 2%
Question 75: A large SM cavity is persisting after an initial extradural posterior fossa decompression. The MRI shows persistent tonsillar herniation. What do you do next?	Observation: 11%
	Redo surgery with extradural technique: 0%
	Redo surgery with intradural technique and duraplasty, without tonsillar reduction: 37%
	Intradural technique with intradural technique and duraplasty, with tonsillar reduction: 50%
	SM shunting: 2%

CMI, Chiari I malformation; SM, syringomyelia; MRI, magnetic resonance imaging.

complications, this individual process of growth can be arrested and even reversed.

The analysis of our data suggests that a critical mass of surgical experience needs to be accumulated before the most technically challenging CMI surgical variants are safely and confidently mastered, while simultaneously lowering the incidence of iatrogenic complications to a point favorably comparable with the extradural technique. We could speculate that this threshold occurs around 500–600 cases for most surgeons, with variations above and below that level as function of individual skill levels. As a corollary, somebody could argue that, to obtain the best possible surgical results, we should probably foster the current trend of channeling CMI cases in specialized dedicated centers. Pushing the point to its limit, maybe we could even consider that the diagnosis and management of CMI, SM, and their related disorders should need to evolve one day into its own separate subspecialty.

The data from this questionnaire showed a wide spectrum of CMI surgical experience. If, on one hand, the less experienced surgeons can be more comfortable with an extradural technique because of their intrinsically low complication rates, then on the other hand the most experienced surgeons (pediatric and adult alike) have been able to master the more technically challenging CMI techniques, with complication rates similar to those of the extradural techniques, while obtaining from their perspective better clinical results. With that premise, the effort of identifying a single surgical technique for CMI, to be regarded and proposed as the standard of care for all neurosurgeons is probably a Sisyphean task.

A more effective approach to the problem would be to be fully aware of a number of simple axioms:

- Each CMI surgical technique has its own pros and cons, in terms of effectiveness and intrinsic risk of complications.
- Although all these techniques do help in various degrees, their results do not make them equivalent, and these facts should not be misrepresented to the patients and their families.
- The actual rate of iatrogenic complications tends to level off across the different CMI surgical techniques, once a certain level of surgical experience has been reached.
- Each surgeon should make his/her own choice on the grounds of individual skillset, training, experience, and personality.
- Each technique should be tailored on the grounds of the specific anatomic and clinical nuances of the individual patient.[13]

CONCLUSIONS

Surgeons who have focused on CMI have been able to accumulate large surgical series, have chosen in their practices the more aggressive (and intrinsically more effective) CMI surgical techniques, and have achieved a low complication rate which compares favorably with that of the extradural techniques.

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