

# Intracranial compliance concepts and assessment: A scoping review protocol

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**Protocol**

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1 *Scoping Review Protocol*

2 *Title:*

3 **Intracranial compliance concepts and assessment: A scoping review protocol**

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29

### 30 **Abstract**

31 **Background:** Monitoring patients with acute brain injury is crucial in neurocritical care.  
32 Intracranial compliance (ICC) has been studied to complement the interpretation of  
33 intracranial pressure (ICP) and help the neurocritical care team to anticipate brain  
34 function deterioration. ICC has been found to be related to compensatory mechanisms  
35 that maintain the stability of ICP (e.g., the higher the compensation, the higher the  
36 compliance of intracranial content to adapt to changes in volume and pressure). However,  
37 ICC has not been properly translated to clinical practice and has remained a critical  
38 technology gap in clinical neuroscience. The objective of this study is to establish a  
39 protocol for a scoping review to map the key concepts of ICC in the literature. In addition,  
40 this study is designed to characterize the relationship between ICC and ICP, as well as  
41 systematically describe the outcomes that are used to assess ICC, considering both the  
42 invasive and noninvasive methods.

43 **Methods:** The scoping review protocol will be conducted according to the Joanna Briggs  
44 Institute's recommendation. The Preferred Reporting Items for Systematic Reviews and  
45 Meta-Analysis Extension for Scoping Reviews will be followed. Animals and humans

46 are considered as the population to be investigated. No age criteria or health condition  
47 will be considered. ICC, as well as the relationship between ICC and ICP, will be  
48 considered as a core concept in this review. Information will be screened based on the  
49 context of neurocritical care. Several databases (PubMed, CINAHL, Web of Science,  
50 EMBASE, Epistemonikos, Grey Literature Report, clinical trial registries, and Cochrane  
51 Clinical Trials) will be searched to identify literature using a combination of keywords  
52 and descriptors, and there will be no restriction on the time frame. Data will be extracted  
53 systematically by the research team and the results will be summarized.

54 **Discussion:** No systematic review has mapped the concepts of ICC and its relationship  
55 with ICP. Providing the key concepts of ICC and the methods of assessment might show  
56 its possible applications in clinical practice and the gaps in research.

57 **Systematic review registration:** Currently, scoping review protocols are not eligible for  
58 registration in the International Prospective Register of Systematic Review database.

59

60 **Keywords:** mapping review, brain compliance, intracranial elastance, brain pulsatility

61

## 62 **Background**

63 The “consensus summary statement of the International Multidisciplinary Consensus  
64 Conference on Multimodality Monitoring in Neurocritical Care” has provided a key  
65 rationale for neurocritical care units around the world [1]. The multimodality monitoring  
66 of patients with acute neurological disorders is a complementary approach to the frequent  
67 bedside examinations and should be considered for the detection of early neurological  
68 worsening before irreversible brain damage occurs and to help clinicians guide

69 individualized therapeutic decisions, which can improve, for example, acute and  
70 long-term prognosis [2].

71 In this sense, the monitoring of intracranial pressure (ICP) has been considered  
72 fundamental to the care of patients with acute brain injury. In the literature, there is a  
73 strong recommendation with moderate quality of evidence that ICP and cerebral perfusion  
74 pressure should be used as a part of protocol-driven care in patients who are at risk of  
75 elevated ICP based on clinical and/or imaging features [1]. The fundamental principles  
76 of raised ICP are condensed in the Monro-Kellie doctrine, in which the volume of the  
77 intracranial cavity is constant under normal conditions and the maintenance of a steady  
78 ICP depends on the volume of the intracranial contents (brain tissue, blood, and  
79 cerebrospinal fluid) [3,4].

80 Methods for ICP monitoring include invasive and noninvasive approaches. Regarding  
81 invasive methods, the external ventricular drain is considered the gold standard for ICP  
82 monitoring [1]. Nevertheless, the efficacy of treatments based on invasive ICP monitoring  
83 regarding improving outcomes such as survival time, impaired consciousness, and  
84 functional and psychological status after hospital discharge is questionable [5]. According  
85 to Chesnut et al. [5], patients diagnosed with severe traumatic brain injury showed no  
86 superior gains when guidelines-based management for monitoring mean values of  
87 intra-parenchymal ICP was used compared to the protocol in which treatment was based  
88 on imaging and clinical examination.

89 On the other hand, intracranial compliance (ICC) or its inverse—intracranial elastance—  
90 has been studied for decades in an attempt to complement ICP interpretation and describe  
91 brain homeostasis more precisely, thus helping the neurocritical care team to anticipate  
92 brain function deterioration [6,7]. ICC has been found to be related to the compensatory  
93 mechanisms used to maintain ICP's stability [4]—for example, the higher the

94 compensation, the higher the compliance of intracranial content to adapt to changes in  
95 volume and pressure. However, ICC has not been properly translated to clinical practice  
96 and this has remained a critical technology gap in clinical neuroscience, probably because  
97 of the number of factors involved in it.

98 Czosnyka and Citerio [6] hypothesized that ICC is a nonlinear function from the  
99 association of venous, cerebrospinal fluid, and arterial pools, with the influence of other  
100 vascular factors such as the regulation of cerebral blood flow, tension of arterial smooth  
101 muscles, partial pressure CO<sub>2</sub>, endothelial function, brain hydration, metabolism, and so  
102 on.

103 Very good reviews are available about ICP monitoring in neurocritical care [4,7], which  
104 are focused on new technological approaches and gaps in research that can be translated  
105 into clinical practice. Nevertheless, nowadays, there is no standardization for ICC  
106 concepts according to invasive and noninvasive techniques.

107 The objective of this study is to establish a protocol for a scoping review, which can be  
108 used to map the key concepts of ICC used in the literature. As secondary questions, this  
109 study is designed to characterize the relationship between ICC and ICP, as well as  
110 systematically describe the outcomes that are used to assess ICC, considering both  
111 invasive and noninvasive methods. Finally, this study will also provide information about  
112 gaps in the body of knowledge to support future studies.

113

#### 114 ***Methods/Design***

115 The scoping review protocol will be conducted according to the Joanna Briggs Institute's  
116 recommendation [8,9]. A priori review protocol is important to improve the transparency  
117 of the searching strategy and peer review process. Unfortunately, scoping review

118 protocols are not eligible for registration in the International Prospective Register of  
119 Systematic Review database. Therefore, considering that scoping reviews are conducted  
120 in an iteratively way to adjust and refine methods throughout the study, this protocol will  
121 serve as a basis for documenting possible changes.

122 The Preferred Reporting Items for Systematic Reviews and Meta-Analysis Extension for  
123 Scoping Reviews, which was developed according to guidelines published by the  
124 Enhancing the Quality and Transparency of Health Research Network for the  
125 development of reporting guidelines, will be followed [10].

#### 126 *Search strategy and data source*

127 A primary but limited search will be performed independently by three investigators  
128 (TLR, GNO, and RMZ) on PubMed (via National Library of Medicine) and CINAHL  
129 databases to analyze the titles, abstracts, and index terms used. The combination of  
130 “intracranial compliance” OR “intracranial elastance” OR “cerebral compliance” OR  
131 “brain compliance” OR “compliance monitoring” AND “intracranial pressure” OR  
132 “intracranial pulse amplitude” OR “intracranial pulse wave” OR “pressure-volume  
133 curve” will be used for this first search. Then the MeSH database will be consulted to  
134 identify and confirm appropriate terms obtained in this first search, which will be included  
135 in the second search strategy.

136 Subsequently, in the second search, all the identified keywords and index terms described  
137 in the first step will be used across the PubMed (via National Library of Medicine),  
138 CINAHL with Full Text (EBSCO), Web of Science (Thomson Scientific/ISI Web  
139 Services), and EMBASE databases. Epistemonikos, Grey Literature Report, clinical trial  
140 registries, and Cochrane Clinical Trials will also be searched. Afterward, as a third step,

141 the reference list of identified studies will be examined for additional sources that can be  
142 included in this review.

### 143 *Selection process*

144 According to Peters et al.'s [9] recommendations, 75% (or greater) level of agreement  
145 between reviewers is necessary before data selection. Therefore, a random sample of 25  
146 titles and abstracts will be selected for screening using the eligibility criteria and  
147 definitions before conducting the second search, and adjustments will be made where  
148 necessary. The screening process will start only after the recommended level of  
149 agreement has been reached.

150 To systematize and organize the search and data extraction, the State of the Art through  
151 Systematic Review (Available from [http://lapes.dc.ufscar.br/tools/start\\_tool](http://lapes.dc.ufscar.br/tools/start_tool)) will be  
152 used. Two reviewers will independently perform the selection process based on the  
153 eligibility criteria. Initially, duplicates will be excluded using the State of the Art through  
154 Systematic Review. Then the potentially eligible articles will be selected based on the  
155 titles and the abstracts. Afterward, these articles will be retrieved for full-text reading to  
156 verify whether they will meet all the inclusion criteria. In cases of disagreements between  
157 the two reviewers, a third reviewer will be consulted to determine the study's eligibility.  
158 The authors will be contacted when access to full-text articles is not available.

### 159 *Eligibility criteria*

160 The main question of this study is based on the population, concept, and context criteria.  
161 Animals and humans will be considered as the population to be investigated, and  
162 information will be organized in subgroups according to their relevance when possible.  
163 No age criteria or health condition will be considered. ICC will be considered as a core  
164 concept in this review, as well as the relationship between ICC and ICP. Both invasive

165 and noninvasive methods for assessment of ICC will be considered. Information collected  
166 will be screened based on the context of neurocritical care. Literature from all countries  
167 will be included.

168 Experimental and epidemiological studies, including randomized controlled trials,  
169 nonrandomized controlled trials, quasi-experimental, before and after studies, prospective  
170 and retrospective cohort studies, case-control studies, and analytical cross-sectional  
171 studies will be included in the analysis. In addition, not only literature reviews such as  
172 narrative reviews, meta-analysis, and systematic reviews but also gray literature (e.g.,  
173 governmental reports, theses, etc.) and theoretical and opinion articles will be considered.  
174 On the other hand, conference abstracts, personal blogs, and social media will be  
175 excluded.

176 For feasibility reasons, the English, Spanish, Italian, Portuguese, and German languages  
177 will be considered. There will be no restriction on the time frame for the collection of  
178 data.

#### 179 *Data analysis*

#### 180 *Data extraction*

181 A standardized electronic data extraction form will be built in the Microsoft Excel™  
182 spreadsheet to obtain key information about the studies that will be included in this  
183 review. The data extracted from each primary study will be as follows: authors, year of  
184 publication, origin/country of origin, aims/purpose, type of literature, research design,  
185 population and demographic characterization, health condition, sample size, methods  
186 used for ICC assessment, and outcomes considered as ICC by authors. Accuracy,  
187 sensitivity, specificity, and other possible comparators will also be extracted and  
188 presented.

189

190 *Data synthesis*

191 Extracted data will be condensed and displayed according to similarities and differences  
192 under the main conceptual categories. Then conclusions will be presented according to  
193 the objectives. The results will be presented as a map of the data extracted, using graphs  
194 and tables. The results will be presented in narrative form. Graphs and tables will be used  
195 for data presentation. Frequency counts of concepts, populations, and methods will be  
196 presented as tables.

197

198 *Discussion*

199 Complementary approaches to ICP monitoring can be a relevant guide that will help the  
200 neurocritical team to accelerate therapeutic decisions to improve the survival and  
201 recovery of patients with acute brain injury. In this sense, ICC monitoring could be  
202 considered as a complementary resource to ICP monitoring and clinical exam. Although  
203 ICC gained much attention in the neurosurgical literature decades ago, it has been barely  
204 used in clinical practice [11]. Nowadays, with the advance of data science and the  
205 interface of cardiovascular and central nervous system researches, different methods are  
206 being used to assess directly or indirectly the intracranial pressure-volume reserve  
207 capacity. However, no systematic review has mapped the concepts of ICC, as well as its  
208 relationship with ICP, considering the invasive and new noninvasive methods. Providing  
209 key concepts for ICC and the methods of assessment might show possible applications in  
210 clinical practice and the gaps in research.

211

212 **Abbreviations**

213 ICC: Intracranial compliance

214 ICP: Intracranial pressure

215

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218

219 **Availability of data and materials:** Not applicable.

220

221 **Ethics approval and consent to participate:** Not applicable.

222

223 **Competing interests:** The authors declare that they have no competing interests.

224

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228 **Authors' contributions:** TLR designed and wrote the initial version of this manuscript.  
229 GNO, RMZ, GHFV, CYH, SB, and DLSJ critically reviewed the manuscript and helped  
230 to refine it.

231

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## Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [PRISMA ScR.pdf](#)