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<u>Original Research Article</u>

Use of Cranial Computed Tomography(CT) in Elderly Patients Presenting after a Fall:

Can We Predict Those Having Abnormal Head CT Scans

Abstract:

Aims: Identify factors predictive of increased risk of intracranial injury and assess the ability of

the non-age related components of the New Orleans head CT criteria (NOC) to guide decision-

making.

Study Design: Retrospective electronic medical record review and application of decision rule

Place and Duration of Study: Emergency Department (ED) of Vidant Medical Center,

Department of Emergency Medicine, Brody School of Medicine at East Carolina University;

Greenville North Carolina, USA; January 2008 through December 2008

Methodology: Electronic Medical Records (EMR) of patients > 65 years of age coming to our

Emergency Department during 2008 with a diagnosis of fall or traumatic injury were reviewed.

Demographics, fall/injury details, risk factors, CT performance, and CT findings were recorded.

Revisit within 30 days was reviewed. Non-age related NOC were applied to the population.

Transfers, known intracranial injury, and multisystem trauma were excluded. Independent

predictors of positive findings were sought using logistic regression.

Results: We identified 783 patients with fall and traumatic injury. Ninety-six met exclusion

26   criteria, leaving 687 for analysis. Three hundred twenty one patients received head CT; 296 met

27   the non-age NOC for head CT. Twelve (3.1%) abnormal head CTs were identified; nine showed

28   an acute finding. Acute findings were not predicted by any independent variable. All 12 of the

29   abnormal head CTs (nine acute, three chronic) were identified by the non-age NOC. Forty five

30   patients presented again within 30 days with no injuries noted.

31   **Conclusion**: Age over 65 did not increase the risk for acutely abnormal head CT in the patient

32   presenting to the ED after a fall. No single factor was predictive of acutely abnormal head CT.

33   The use of the non-age related NOC predicted those patients having an abnormal head CT with

34   100% accuracy. Age may not independently necessitate head CT after a fall.

35

36   **Key Words**: computed tomography, decision rules, elderly, fall, head injury,

37

38   INTRODUCTION

39   In 2004, injuries resulted in 31 million emergency department (ED) visits, representing

40   32% of all visits. Elder patients are at highest risk for both fatal and nonfatal injuries with

41   mortality and hospitalization rates for injuries reported to increase dramatically.[1,2]. Falls are

42   the most common mechanism of injury for older patients visiting the ED and are the most

43   common cause of injury-related death [1,2]. Several widely used evidence based decision rules

44   [3-10] using a general population indicate that age over 60 or 65 years places the patient at high

45   risk for an abnormal head CT after a mild head injury. The various decision rules have been

46   compared to determine if one more readily differentiates the patient who will benefit from head

47   CT [11-13], but none specifically address only the population of patients over age 65 who

48   potentially have an intracranial injury, particularly after a fall. Currently no definitive evidence

49   exists as to how to evaluate elderly patients after a fall. Due to the general increased incidence

50   of injury, and specifically closed head injury, head CT is frequently ordered [14]. However, CT

51   scans are costly and are now recognized to carry a radiation risk [15, 16].

52   Head CTs ordered because of a fall account for the expenditure of millions of dollars

53   annually in the United States [3]. To contain costs while providing excellent care, it is important

54   for emergency physicians to know if patients will benefit from head CT. We retrospectively

55   searched for elderly patients who fell and are considered at increased risk for intracranial injury,

56   based upon current decision-making strategies. We sought to define risk factors for acutely

57   abnormal head CT in these elder patients after a fall, as it is the most common mechanism of

58   mild blunt closed head injury and applied the non-age related NOC to the population receiving

59   head CT scans. We hypothesized that application of the non age NOC to the elderly population

60   will reduce the head CTs ordered in this population without compromising care.

61

62   MATERIAL AND METHODS

63   The study was conducted in the ED of a teaching hospital and Level I Trauma Center in

64   the Southeastern United States with an annual census of 90,000 patients during 2008. All

65   patients greater than 65 years of age presenting to the ED or its Fast Track area from January 1,

66   2008 to December 31, 2008 with ICD-9 code for "fall" or "traumatic injury" (958.0-959.0) as the

67   final diagnosis were eligible for inclusion. Patients under 65 years of age, those received in

68   transfer from another medical facility or accepted as a patient with multi-system trauma were

69   excluded from analysis. Physician judgment and standard accepted medical practice determined

70   whether a patient received a head CT scan. Prior to collection of study data, ten charts were

71   randomly selected and all investigators extracted the prescribed data from each chart.

72   Comparisons of the data obtained by each investigator were made to assess consistency in

73 interpretation of patient records and findings. The kappa statistic for inter-rater reliability was

74 0.86 and demonstrated good reliability. EMR were retrospectively reviewed by three of the

75 investigators (JB, RJ, CB) and data collected on a standardized form. Two investigators (NN,

76 MA) applied the non-age NOC to the study population (Table 1).

77

78   Table 1:   New Orleans Head CT rules: Presence of any of the following indicates the
79   need for head CT [6]:
80
81   Trauma above the clavicles
82   Altered memory
83   Intoxication
84   Headache
85   Vomiting
86   Seizure activity
87   Age > 60 years (N/A in this study)
88

89 The following data was collected: age, gender, type of fall, presence of dementia, anticoagulant

90 or aspirin use, presence of/type of injury above the clavicle, performance of head CT, acute

91 finding on head CT, return within 30 days, reason for return, head CT at return visit, and acute

92 findings present at return visit. Type of fall was characterized as: fall from bed, from sitting,

93 from standing or from height above ground. Dementia was noted from the patient's past medical

94 history or the current provider's note. A patient was considered to have a memory deficit if they

95 had a change from their baseline memory status. Headache was any reported head pain,

96 localized or diffuse. Intoxication was determined as per the treating physician's documentation.

97 If intoxication was not reported then the patient was deemed not intoxicated. Seizure activity

98 included any suggestion of seizure. Anticoagulants were categorized as: aspirin, clopidogrel,

99 warfarin, fractional based or low molecular weight heparin. Presence, location, and type of

100 injury were noted from the physician's note and the discharge or admission diagnoses recorded

101 in the chart for that visit. Trauma above the clavicles was considered as any physical evidence of

102 trauma above the clavicles. Vomiting was present if noted in the chart. If the treating physician

103 was unable to obtain any information it was noted as "unable to obtain". Radiologists' official

104 readings were used to assess presence of abnormal head CT. The word "acute" needed to appear

105 in the radiology report describing the intracranial findings for the image to be considered

106 "positive". The NOC were first applied to the positive scans to determine if they would have

107 been detected using the rules. The same rules were applied to patients with normal head CT

108 scans to evaluate for potential reduction, if any, in total head CTs ordered. Neither cognitive nor

109 psychometric testing was performed due to the retrospective nature of the investigation.

110 Consensus among abstractors regarding collection and recording was reached by periodic

111 discussions as needed.

112   Chi square analysis was used for the dichotomous variables of gender, presence of

113 dementia, anticoagulant use, type of fall, and injury above the clavicle. Regression analysis was

114 used to determine if any of the historical or physical examination variables were independent

115 predictors of intracranial injury. Statistical analysis was performed using STATVIEW (SAS,

116 Inc). This study, UMCIRB #08-0773, was reviewed and deemed exempt by the University and

117 Medical Center Office for Human Research Integrity. Patient privacy and confidentiality of

118 medical record information was the only ethical consideration deemed necessary.

119

120 RESULTS

121   Patients ranged in age from 65 to 98 years. Out of 687 reported falls, 321 cranial CTs

122 were performed (46.4%). The mean age of patients receiving head CT after fall was 81.4 years

123 (range 65-98). No difference in age existed between those with acute intracranial findings vs.

124 those without acute findings (P= 0.67). Only nine (2.8%) of the 321 scans showed evidence of

125 acute intracranial injury (Figure 1) with 33 extra-cranial findings noted: scalp hematoma

126 (n=sixteen), soft tissue edema (n=seven), sinusitis (n=five), facial/orbital fracture (n=four), and

127 cervical spine injury (n=one). Two stable/chronic subdural hematomas and one stable hygroma

128 were noted making twelve patients with abnormal CT scans. Of the acute intracranial injuries,

129 none required neurosurgical intervention but seven (78%) were admitted to the hospital for

130 physical, occupational, or speech therapy. Two were made Do Not Resuscitate by family

131 members.

Charts Included — N=687

CT Scan Performed — Yes=321, No=366

Type of Fall — Bed n=36, Sitting n=54, Standing n=211, Height n=17

Injury above Clavicle — Yes=20, No=16 (Bed); Yes=22, No=31 (Sitting); Yes=132, No=76 (Standing); Yes=6, No=11 (Height)

Intracranial Injury — n=0, n=0 (Bed); n=2, n=0 (Sitting); n=3, n=3 (Standing); n=1, n=0 (Height)

Type of Injury — ICH (2) (Sitting); SAH (2), IVH (1) (Standing Yes); SDH (2), SD Hygroma (1) (Standing No); SDH (Height)
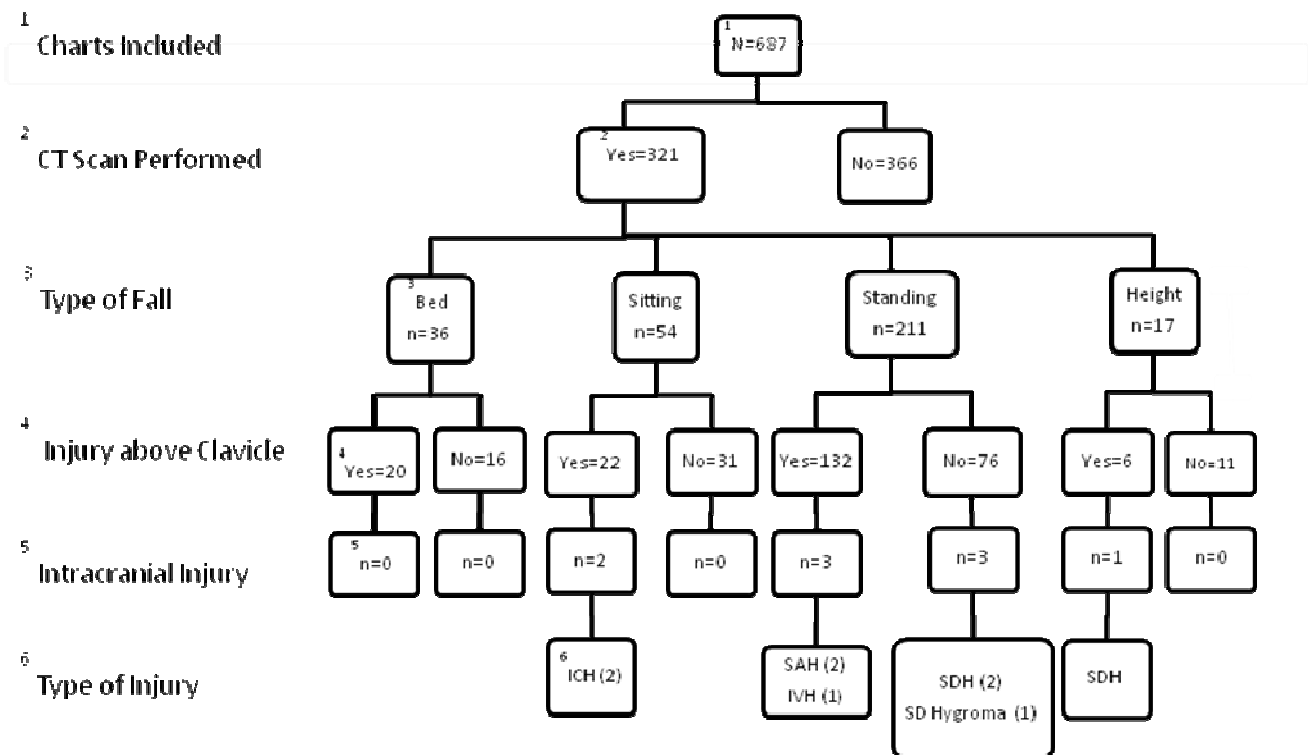
132

133 Figure 1: Flow Chart of patients included in the study and final outcomes

134 ICH=intracranial hemorrhage; SAH=subarachnoid hemorrhage; IVH=intraventricular

135 hemorrhage;SDH=subdural hematoma

136

137

138 Forty-five patients presented again within 30 days, primarily for wound checks. No new

139 abnormal CT scans were noted upon return visit. Sixty seven percent (six of nine) of the

140 intracranial injuries occurred in patients with visible injury above the clavicles, although this did

141 not prove to be an independent predictor of acute CT findings (p=0.20). None of the

142 independent variables were predictive of acutely abnormal head CT (Table 2).

143

144 **Table 2: Comparison of patients with positive CT findings vs. patients with no acute CT**

145 **findings**

Variable	No Findings on CT	Acute Findings on CT	P-value
Age (years)	80.0±7.7	81.3±8.3	0.67
Gender	79% Female	67% Female	0.41
Presence of Dementia	141 (44.0%)	4 (1.8%)	0.40
Aspirin Use	149 (46.7%)	6 (1.9%)	041
Injury above clavicle	189 (58.9%)	6 (1.9%)	0.20
Fall from Bed	36 (11.3%)	0 (0%)	0.31
Fall from Sitting	52 (16.3%)	2 (0.6%)	0.19
Fall from Standing	205 (64.5%)	6 (1.9%)	0.68
Fall from Height	16 (5.0%)	1 (0.3%)	0.52

146
147 Using the non-age items of the NOC, EMR of 296 patients receiving head CTs were able to be

148 reviewed. 123 (45%) had a history of dementia. Only 36 (15%) of the 238 patients in whom

149 complete events about the fall were ascertained were reported to have had alteration of

150 consciousness. All twelve of the patients with abnormal head CTs (nine acute, three chronic)

151 were identified by application of the non-age NOC. (Table 3)

152 **Table 3: Non-age Related New Orleans Head CT Rules Patient Findings**

153

	Patients without Head CT Abnormalities			Patient with Head CT Abnormalities		
	Total	N#	percent	Total	N	percent
Trauma above the clavicles	174	284	61	11	12	92
Altered memory	12 *	281	4	3	12	25
Intoxication	11	284	4	1	12	8
Headache	80	246	33	6	11	55
Vomiting	9	257	4	0	12	0.0
Seizure Activity	1	255	0.3	1	12	8

154 #Total number of responses different based on ability of physician to obtain information from patient or witnesses

155 *Six patient with impaired short term memory, Three patients with newly diagnosed confusion, Six Patients with worsening of baseline

156 confusion, Three patients with unknown baseline mental status

157

158 The finding most frequently associated with abnormal head CT was trauma above the clavicle.

159 Strict application of the non-age NOC to this population would have reduced the number of

160 patients receiving head CTs by 20% without missing any abnormal head CTs (Table 4).

161 **Table 4: Calculated Reduction of Head CT scans by patient history and attributes**

	All Patients (N=296	Patients with Abnormal Head CT (N=12)
New Orleans Head CT rules **Alone**	59 (20%)	0
New Orleans Head CT rules, **Adding** History of Dementia	32 (10%)	0
New Orleans Head CT rules , **Adding** Fall from height and Anticoagulation	48 (16%)	0
New Orleans Head CT rules, **Adding** Fall from height, Anticoagulation and History of Dementia	24 (8%)	0

162 *If information was unable to be obtained from a patient the patient was considered to require a head CT scan for further evaluation

163   Addition of dementia, fall from height, or current anticoagulation therapy to the non-age NOC

164   produced a lesser reduction in CT scans ranging from 8-16% as shown in Table 4 above. Data

165   for antiplatelet and anticoagulation therapy are shown in Table 5.

166

167   **Table 5: Anticoagulation and Antiplatelet Therapy**

	No Acute Abnormality N=284	Total Head CT Abnormalities N=12	P
Antiplatelet Therapy*	147 (52%)	9 (75%)	0.24
Anticoagulation Therapy#	33 (12%)	1 (8%)	0.79

168   *Aspirin or Plavix Therapy
169   # Warfarin or Heparin product
170

171   DISCUSSION

172   Clinical decision rules often use age as an exclusion criterion due to a higher reported

173   incidence of injury in elderly adults, contributing to a significant amount of cranial imaging in

174   this population with mostly negative results [17]. It will be important to better define the

175   population of elderly patients in whom imaging may not be necessary after a fall. Much work

176   has been done regarding decision-making and whether a patient is at high, medium, or low risk

177   for intracranial injury after a minor head injury. All have concluded that age of >60-65 years

178   places the patient at high risk and recommend imaging [3-10]. None have attempted to isolate the

179   population of patients over age 65 years who have an apparent minor head injury.

180   Neurosurgical significance is frequently used in descriptions of primary outcome measures

181   involving a range of 0.1% to 6% as well as clinically important brain injury ranging from 6% to

182   15-20%. Our study population had a neurosurgical intervention rate of zero percent, with 78% of

183   the injuries judged clinically important based upon information from Stiell and colleagues [18].

184   While the incidence of falls in our study was consistent with epidemiological reports, we

185   found a low incidence (2.8%) of positive scans. Our selected clinical variables were identical to

186   those included in all the studies cited and included additional variables specific to the elderly

187   population (anticoagulation and dementia). None of the independent variables we selected

188   proved to be associated with abnormal head CT, either due to the mechanism of simple fall and

189   its associated low kinetic energy or the low number of positive scans. Injury above the clavicle

190   was closest to reaching statistical significance. A post-hoc power analysis indicated that 45

191   positive scans would be needed to make this a significant predictor at(P=0.05) with 90% power

192   and an additional 1650 scans or approximately four to five years of patient EMR would need to

193   be assessed.(Power Analysis for Proportions in GB STAT, Dynamic Microsystems; Silver

194   Spring, Maryland) Our small number of positive findings is consistent with other studies

195   involving minor head injuries [6, 19], reiterating the low frequency of abnormal head CT scans

196   in patients with minor head injuries and emphasizing that abnormal head CT resulting from falls

197   is rare. The majority of patients in our study had no alteration of consciousness and were at their

198   baseline mental status when they presented to the ED. These findings have been shown to be

199   good prognostic factors in patients with minor head injuries [19].

200   One goal of this study was to evaluate if the non-age NOC are effective when used with

201   elderly patients presenting after falls. Using the intention to treat model, when components of

202   the NOC were unable to be obtained, the patients required a head CT scan. When the non-age

203   NOC were applied to patients with abnormal head CT scans, all were detected. If these

204   components of the NOC had been strictly applied to the population at presentation there would

205   have been 20% fewer head CT scans ordered. This reduction is highly dependent upon obtaining

206   reliable histories from patients or witnesses for patients with dementia; admittedly a major

207   difficulty for physicians. A large number (46%) of patients had dementia and the NOC could be

208   applied to a significant number of patients in this study with severe dementia only with the

209 contribution of witnesses, as the patient was unable to provide details of the fall. Fortunately, the

210 components of the NOC were able to be obtained for 64% of patients with dementia. Patients or

211 caregivers were able to describe events during or after the fall, as well as relate current mental

212 status to baseline mental status. With the low number of abnormal head CT scans we further

213 evaluated the NOC performance by incorporating high-risk patients. Nagurney et al [20] showed

214 that elderly patients fall from a height or down stairs less frequently but these falls are more

215 likely to result in abnormal head CT scans. The effect of anticoagulation on the likelihood of

216 abnormal head CT scan is less clear [21-23]. Our data found no increased frequency of abnormal

217 head CT in patients taking anticoagulant therapy. When the patients on anticoagulation therapy

218 or with falls from a height are excluded and the NOC applied, there is a modest 16% reduction in

219 head CT. If all patients with dementia are excluded from consideration and scanned, there is only

220 an eight percent reduction in head CT scans ordered.

221   In the major studies and recommendations, some period of altered consciousness has

222 been used as an indicator of head injury. Our study found that momentary alteration of

223 neurological function may not be a sufficient indicator of head injury. Only a minority of

224 patients had alteration in consciousness (15%), however 50% (six of twelve) of patients found to

225 have abnormal head CT did not report any alteration in consciousness. Therefore, alteration in

226 consciousness was not useful in determining if imaging was needed; a finding that only adds to

227 the current lack of clarity when evaluating elderly patients for head injury. An acutely abnormal

228 head CT may be present despite not having a period of altered consciousness used to clinically

229 define head injury. All elderly patients that present after trauma should be carefully assessed

230 clinically for signs of intracranial injury. These findings will guide whether to obtain imaging in

231 their evaluation. Among our physicians, dementia/inability to assess mental status,

232 anticoagulation, and injury above the clavicles were the most common reasons cited for ordering

233 head CT for an elderly patient with a fall. While 34% of those without dementia were scanned,

234 66% of those with dementia were scanned (P=0.001). This difference held true for

235 anticoagulation with aspirin (55% scanned on aspirin vs. 45% not on aspirin (P=0.01) and injury

236 above the clavicle (75% scanned with injury vs. 25% scanned without injury (P=0.001)).

237 However, none of these variables were predictive of intracranial injury.

238   As physicians, "The fear of failing to identify brain injury has led to the liberal and

239 excessive use of CT scanning of patients with blunt head trauma who have even a remote

240 possibility of intracranial injury" [5]. This is now coupled with concerns of cumulative radiation

241 exposure to the individual patient. The use of any diagnostic modality needs to be justified by

242 improving healthcare outcomes and the cost of medicine. This aspect of geriatric emergency

243 medicine seems promising as an area of investigation. Evidence based guidelines are needed to

244 provide assistance in the evaluation of elderly patients for acute intracranial injury after suffering

245 a fall.

246   The low rate of positive findings in our study suggest an underpowered study, however it

247 may simply reflect the mechanism of injury alone. Higher velocity injuries were included in the

248 studies referenced, whereas this study limited the population to elderly patients with a simple

249 fall. The number of visits and scans performed are still similar to those studies cited in the

250 creation of the existing decision strategies yet the frequency and severity of injury was much

251 less. Our finding of only 2.9% intracranial injuries is lower than previously reported and may

252 simply reflect this different mechanism of injury.   Our study included only patients with a

253 simple fall, a very common source of injury in the elder population, whereas studies validating

254 implementation of the published decision rules included patients incurring injury from high

255   velocity injuries as well as patients under 65 years of age. Post-hoc power analysis revealed that

256   an additional 1650 CT scans, approximately four to five years of patient EMR, would need to be

257   reviewed to obtain significance in the variables analyzed at (P =0.05) with 90% power.(Power

258   Analysis for Proportions in GB STAT, Dynamic Microsystems; Silver Spring, Maryland)

259   Our data are therefore not intended to be generalizable to all ages of patients, those

260   previously studied, or those with different mechanisms of injury. Patients living in long-term

261   care facilities have been reported to have an increased risk of falling [19, 20].   We did not

262   include "location of fall", such as nursing home, assisted living facility, personal home, or public

263   place, and may have introduced selection bias against a patient with a higher level of

264   independence. It is also possible that we did not capture everyone that sought fall-related

265   medical care or presented again within 30 days after their ED discharge at the time of initial

266   injury. The retrospective design precluded us from cognitively assessing patients for post

267   concussive symptoms or conditions developing after 30 days. However, as the data collection

268   began in the spring of 2009 and the last patient included was from December 31, 2008 as well as

269   being the only hospital in the county and the primary regional referral source for our area of the

270   state we feel that we would have detected all patients returning to our facility within 30 days of

271   injury.

272   CONCLUSION

273   A low incidence of acutely abnormal head CT scans exists in the population of patients over 65

274   years of age after a fall. No single factor predicted the patient with an acutely abnormal head

275   CT. The non-age related components of the NOC predicted all (100%) of the patients that had

276   an abnormal head CT; and if applied strictly would have decreased the number of head CTs

277   ordered by 20%. Dementia, trauma above the clavicle, and anticoagulant usage by the patient

278   were associated with performance of head CT by the emergency physician but not with the

279   presence of intracranial injury.

280

286   Authors' Contributions:

287   Charles K. Brown, MD: origination of the idea; assisted design of data collection instrument; data
288   collection of single risk factors; manuscript preparation and submission; senior and corresponding
289   author

290   Jennifer M. Bennett, MD: design of data collection instrument; data collection of single risk factors;
291   manuscript preparation

292   Nathan R. Nehus, MD: application of the New Orleans Criteria to the data set; manuscript preparation

293   Matthew R. Astin, MD: application of the New Orleans Criteria to the data set; manuscript preparation

294   Reuben Johnson, MD: design of data collection instrument; data collection of single risk factors;
295   manuscript preparation

296   Kori L. Brewer, PhD: assisted design of data collection instrument; data analysis; statistical analysis;
297   manuscript, Table, and Figure preparation; assisted manuscript submission

298   This research was approved as exempt by the University and Medical Center Institutional
299   Review Board, UMCIRB#: 08-0773.

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