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External ventricular drainage preceding the removal of a nail from the intracranial space as a safe management strategy for predicted secondary intraventricular hemorrhage

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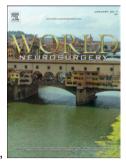
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16	PhD.
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20	drainage, computed tomographic angiography and venography
21	
22	List of abbreviations:
23	ICNGI; intracranial nail gun injury, CT; computed tomography, CTA; computed tomography angiography, CTV;
24	computed tomography venography, IVH; intraventricular hemorrhage
25	
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30 Abstract

Background: Intracranial nail gun injury is a rare traumatic event and can result from a suicide attempt. Cerebral angiography is essential in the evaluation of damage to the intracranial vessels, and surgical removal of nails is generally the optimal treatment. Intraventricular hemorrhage can happen following removal of intracranial nails. Endovascular surgery or intraoperative computed tomography has been reported to be useful for detection and treatment of intraventricular hemorrhage. After the surgical removal of nails, attention should be paid for complications such as pseudoaneurysm and infection.

Case description: A-63-year-old man with a history of depression was transferred to our hospital in an unconscious state. Physical examination showed two nails puncturing his left thorax, and computed tomography revealed a nail puncturing the intracranial space. No damage to these intracranial vessels was observed on computed tomography angiography and venography. Following drainage for potential intraventricular hemorrhage, the nails were removed. Postoperatively, prophylactic antibiotic therapy was administrated for secondary infection. Computed tomography angiography did not detect any postoperative pseudoaneurysms. The patient also underwent therapy from a psychiatrist, and was transferred to another hospital.

44 **Conclusion:** As for treatment of a case of intracranial nail gun injury, our case shows that preoperative cerebral 45 angiography is not always needed in intracranial nail gun injury when there is no apparent damage to the intracranial 46 vessels and emergent removal of nails is required. External ventricular drainage preceding the removal of a puncture 47 object can be an effective management strategy for secondary intraventricular hemorrhage.

48

49 Introduction

50Intracranial nail gun injury (ICNGI) has been reported as a relatively rare trauma injury¹⁻⁹, and is categorized as low-velocity missile trauma event^{3,10}. ICNGI has a relatively low mortality and morbidity, compared to a 51high-velocity missile trauma event such as gun shot injury^{3,10}. Complications of ICNGI include vascular injury and 5253intracranial hemorrhage in the acute phase; and pseudoaneurysm, seizure and infection from the subacute phase to the chronic phase^{1,2,7,10}. ICNGI has been reported as an accident and as the result of a suicide attempt^{4,5,8,10}. For cases 54of the latter, psychological therapy is needed to prevent a suicide reattempt ^{4,5,10}. ICNGI accompanied with other 5556trauma such as an intrathoracic nail injury has been reported, but seems to be uncommon⁹. We report a case of 57ICNGI accompanied with intrathoracic nail gun injury resulting from a suspected suicide attempt.

58

59 Case report

60 A 63-year-old male carpenter with a past history of depression was transported to our hospital. He was found 61unconscious lying in the yard of his home with two nails puncturing his left precordium. A contused wound was 62seen in the right temporal region, but no apparent nail tail was observed. His Glasgow coma scale (GCS) on arrival 63 was E3V2M6. His vitals were stable, but respiratory sounds were not heard in the left precordium. The patient was 64 intubated and two thoracotomy tubes were placed in the left thoracic cavity. Whole-body CT with contrast medium 65was performed. Computed tomography (CT) revealed two nails in the left thoracic cavity, near the heart and the 66 aorta, respectively (Figure 1A). In addition to the nails in the left thoracic cavity, another nail of 9 cm in length was 67 detected spanning from the right temporal lobe to the left thalamus with traumatic subarachnoid hemorrhage. 68 Intraventricular hemorrhage (IVH) was also seen in the right lateral ventricle (Figure1B and 1C). As CT 69 angiography (CTA) and CT venography (CTV) did not reveal any apparent damage of the major intracranial vessels 70 (Figure 1D and 1E), emergent removal of the nails in the left thoracic cavity and the head was performed.

71 Operation

72The patient was set in the lateral position and left thoracotomy was performed. After removal of two nails in the left 73thoracic cavity, laceration of the left pericardium was observed. Apparent bloody pericardium effusion, which might 74cause cardiac temponade, was not seen, and there was no evidence of injury of the coronal arteries. The pericardium 75was sutured and the wound was closed. The patient was then set in supine position, and external ventricular drainage 76was undertaken in consideration of a possible increase in intracranial pressure following IVH with the removal of 77the nail from the intracranial space. After external ventricular drainage, small craniotomy around the entrance point 78of the intracranial nail was performed (Figure 2A, 2B and 2C). The intracranial nail was manually removed and 79secondary bleeding from the removal point or external ventricular drain were not observed.

80 Postoperative clinical course

81 The patient was admitted to the intensive care unit, and tetanobulin and tetanus toxoid were injected.

Ceftriaxone of 2g/day and metronidazole of 1.5g/day were also administrated to avoid secondary infection. The postoperative course was uneventful. Postoperative CT and CTA on POD 21 did not show secondary IVH or delayed pseudoaneurysm (Figure 3A and 3B). Considering his medical history of depression, the cause of ICNGI was suspected as a suicide attempt, and we requested a psychiatrist for ongoing examination. Two months after the

- operation, the patient was transferred to another hospital for rehabilitation. At the time of writing the patient had not
 reattempted suicide.
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- 89

90 Discussion

91 We presented a case of ICNGI. Several cases of ICNGI have been reported as its use has increased in the 92 workplace or home, as an accident or suicide attempt¹⁻⁹.

93Prior to surgical removal of nails, preoperative radiological evaluation is indispensable. An intracranial nail was 94found by secondary CT investigation in our case. Multiple nail injury to the head and the trunk have been also 95reported⁹. Whole-body CT for trauma should be performed, especially when the cause of the traumatic event is not 96 clear. To evaluate intracranial vascular resulting from nail puncture, cerebral angiography is essential⁷. However, 97 when the injury of vital organs is suspected due to nail puncture, emergent surgical removal of nails is desirable, as 98 seen in the left thoracic cavity in our case. Evaluation of major intracranial vessels with CTA has been acceptable 99 when CTA does not show evidence of injury of the major intracranial vessels injury by nail puncture³. Cerebral 100angiography can be an acceptable replacement for CTA and CTV for the emergent removal of nails in patients 101without apparent injury of the intracranial vessels.

As for the operative management of a penetrating head injury, the following procedures have been proposed such as removal of the penetrating object, removal of bone fragments, debridement, dural repair and endovascular intervention^{7,11-13}. Preceding external ventricular drainage, which we performed prior to the removal of the intracranial nail in our case in order to avoid an increase in intracranial pressure as a result of IVH, seems to be uncommon.

107 In a case described by Rezai et al., external ventricular drainage, prior to removal of a penetrating nail, was 108 performed for acute hydrocephalus with intraventricular and subarachnoid hemorrhage¹⁴. The patient in this case 109 died, but the outcome in this case does not suggest that preceding external ventricular drainage is not useful. The 110 cause of the death was a pseudoaneurysm and vasospasm of cerebral arteries .

Secondary IVH or ventricular tract hemorrhage after removal of a penetrating object has been reported¹⁵. Nathoo et al. reported that IVH was related to poor outcomes in the patients of a penetrating head injury¹⁶. Continuous increased intracranial pressure could be a cause for poor outcomes in the patients of penetrating head injury.

114 External ventricular drainage can reduce intracranial pressure after secondary IVH associated to nail removal.

115Real time endovascular assistance and intraoperative CT have been reported as effective measures for detection and treatment of secondary IVH after removal of penetrating object ^{6,17}. Treatment in the hybrid operation room is 116 117now also an option. However, intraoperative CT and the hybrid operation are not available in all institutes, and nor 118are these suitable for every case of intracranial nail gun injury. Furthermore, real time endovascular assistance can 119be risky for nails located near the heart or the aorta, which are often an access route for intracranial lesions. When 120secondary IVH is predicted, in order to avoid increased intracranial pressure with secondary IVH after removal of 121penetrating objects, preceding external ventricular drainage can be an effective and safe method of management. As 122for the limitation of our proposition, preceding external ventricular drainage lacks of statistical data based on 123randomized trials. Second, as external ventricular drainage is a palliative procedure for increasing intracranial 124pressure, another homeostatic procedure may need if continuous bleeding is observed. Therefore, the indication of 125preceding IVH should be assessed in each individual case.

126To optimize the clinical outcomes after surgery, attention must be given for postoperative care such as prevention of 127secondary infection, detection and treatment for delayed pseudoaneurysm and psychiatric support. Occurrence of 128infectious complications after penetrating head trauma is high, and the use of broad-spectrum antibiotic prophylaxis 129is recommended. In our case, ceftriaxone and metronidazole were administrated for 14 days and secondary infection 130did not occur. As traumatic pseudo aneurysms associated with penetrating brain trauma are reported with a high 131mortality, follow-up radiological imaging is essential. Traumatic pseudoaneurysm can be detected on average within 2 to 3 weeks after injury, but can occur months after the injury^{1,7,18}. In our patient, delayed pseudoaneurysm was not 132133apparent on CTA. However, if an intracranial psuedoaneurysm is suspected on CTA, cerebral angiography should be performed and direct clipping or endovascular treatment considered¹⁸. ICNGI have been reported in patients with 134a history of mental disorders^{5,8,10}. If ICNGI is suspected as result of a suicide attempt like our case, postoperative 135136psychiatric assessment and treatment is required to prevent a suicide reattempt.

137 Conclusion

We reported a case of ICNGI related to possible suicide attempt. CTA and CTV can be sufficient as preoperative intracranial evaluation when no apparent damage of intracranial vessels is observed and emergent removal of nails is required. External ventricular drainage preceding nail removal from the intracranial space may be an effective and

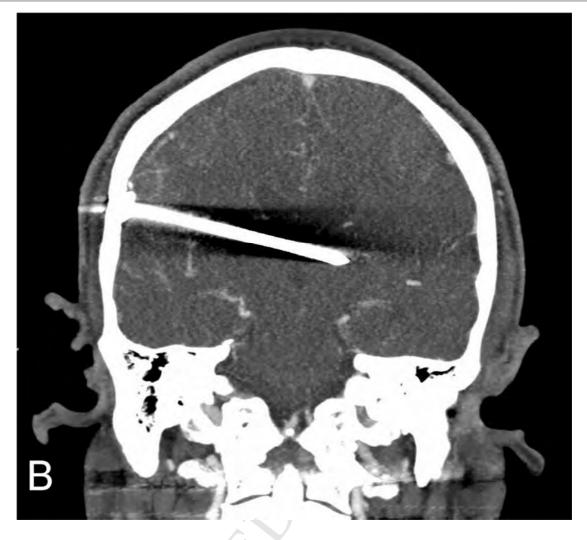
141	safe management strategy when secondary IVH is predicted. Psychiatric support is also mandatory to avoid a suicide
142	reattempt.
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146	
147	Highlights
148	• A case of intracranial nail gun injury accompanied to intrathoracic nail gun injury was reported.
149	· Computed tomography angiography can be replaceable for cerebral angiography if surgical removal of nails is
150	considered to be emergent.
151	• Preceding external ventricular drainage can be an option before removal of intracranial nail, especially without
152	support of endovascular treatment or intraoperative computed tomography.
153	
154	Figure legends
155	
156	Figure 1.
157	A) Preoperative CT revealed two nails in the left thoracic cavity, near the heart and the aorta. B) Head CT revealed
158	another nail of 9 cm spanning from the right temporal lobe to the left thalamus with traumatic subarachnoid
159	hemorrhage. C) IVH was confirmed in the right lateral ventricle (black arrow). D), E) CTA and CTV did not reveal
160	apparent damage of major intracranial vessels.
161	
162	Figure 2. Intraoperative images.
163	A) Small craniotomy around the entrance point of the intracranial nail was performed. B) The intracranial nail was
164	manually removed. C) Secondary hemorrhagic event was not apparently observed from the removal point.
165	
166	Figure 3. Postoperative radiological images.
167	A) IVH was not increased on postoperative CT. B) Delayed pseudoaneurysm was not evident on CTA performed on
168	postoperative day 21.

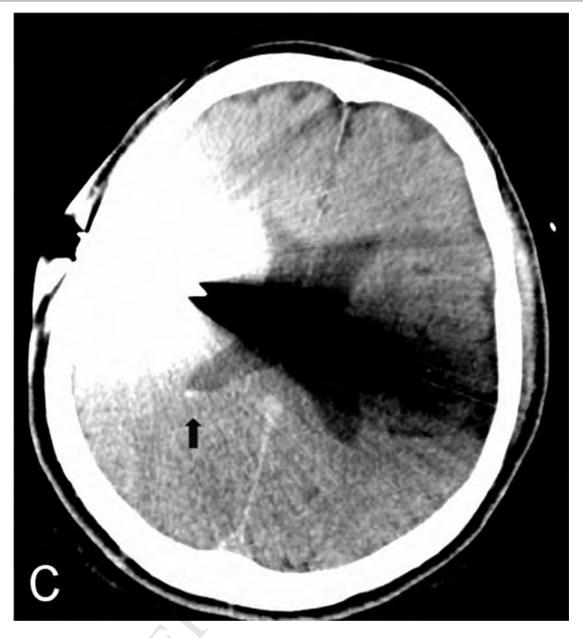
171 **Reference**

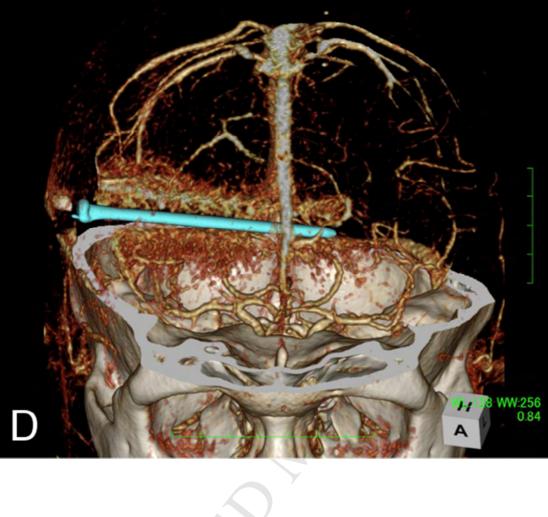
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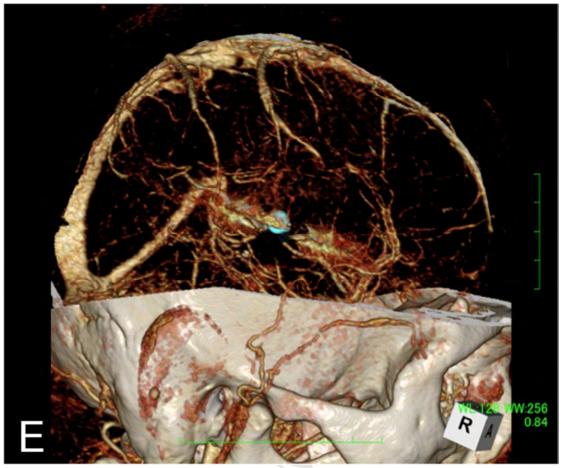
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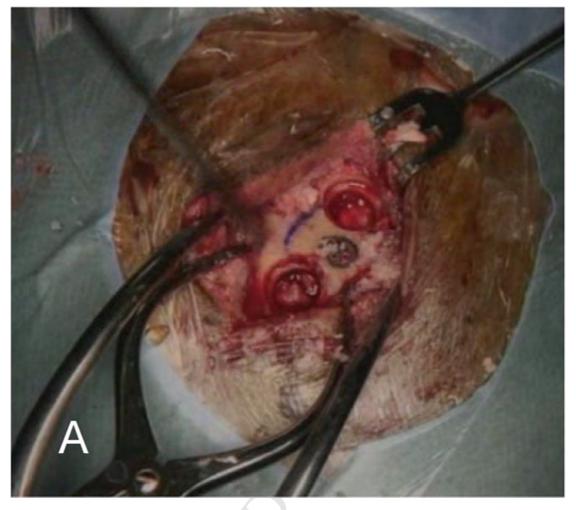




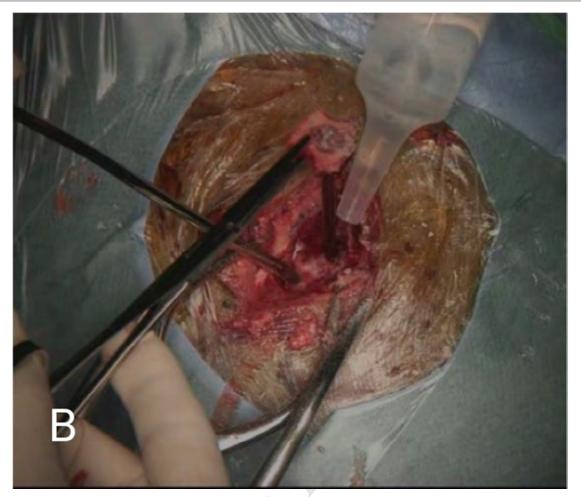








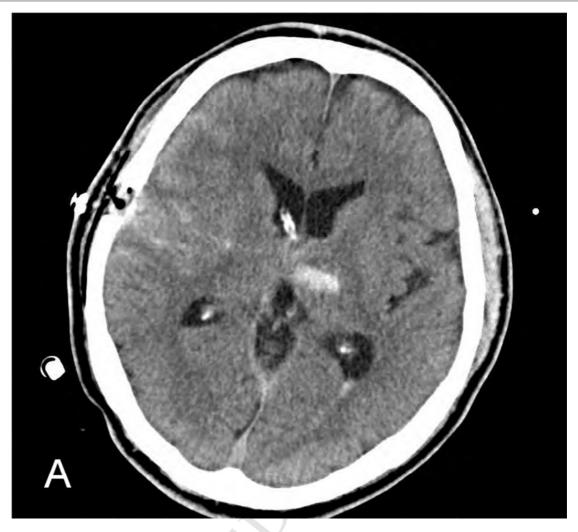
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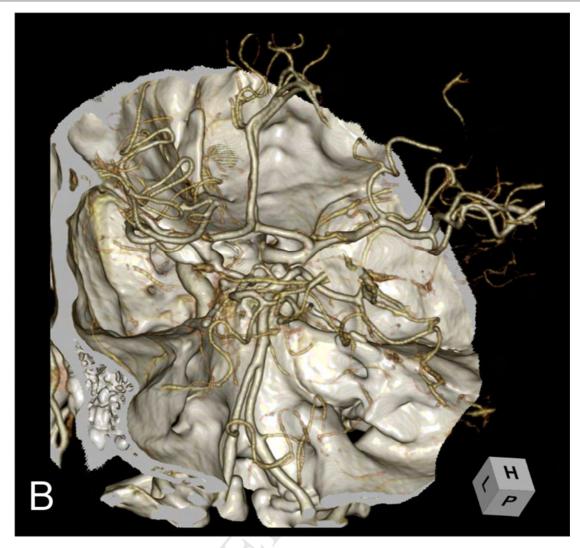


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Highlights

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- · Computed tomography angiography can be replaceable for cerebral angiography if surgical removal of

nails is considered to be emergent.

· Preceding external ventricular drainage can be an option before removal of intracranial nail, especially

without support of endovascular treatment or intraoperative computed tomography.

List of abbreviations:

ICNGI; intracranial nail gun injury, CT; computed tomography, CTA; computed tomography

angiography, CTV; computed tomography venography, IVH; intraventricular hemorrhage