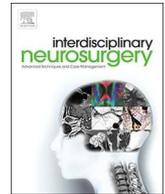




ELSEVIER

Contents lists available at ScienceDirect

## Interdisciplinary Neurosurgery

journal homepage: [www.elsevier.com/locate/inat](http://www.elsevier.com/locate/inat)

## Case Reports &amp; Case Series

## An unusual case of waterskiing-related acute subdural hematoma in an adolescent treated with endoscopic assisted hematoma evacuation

Hideaki Abe<sup>a</sup>, Jun Maruya<sup>a,\*</sup>, Keiichi Nishimaki<sup>a</sup>, Yukihiko Fujii<sup>b</sup><sup>a</sup> Department of Neurosurgery, Akita Red Cross Hospital, Akita, Japan<sup>b</sup> Department of Neurosurgery, Brain Research Institute, Niigata University, Niigata, Japan

## ARTICLE INFO

## Keywords:

Acute subdural hematoma  
Adolescent  
Waterskiing  
Rotational acceleration injury  
Endoscopic assisted evacuation

## ABSTRACT

We report the case of waterskiing-related acute subdural hematoma (ASDH) in an adolescent who was successfully treated with endoscopic assisted hematoma evacuation. An 18-year-old male sustained head injury during waterskiing and was referred to our hospital. He had a history of traumatic subarachnoid hemorrhage two years ago. Neurological examination showed mild left hemiparesis and altered consciousness. Computed tomography (CT) indicated ASDH. Cranioplastic craniotomy following rapid mannitol infusion was performed. After dural incision, a rigid endoscope was introduced through the craniotomy, and a malleable suction cannula was used to evacuate the hematoma. Postoperative CT showed near-complete evacuation. The postoperative course was uneventful, and the patient was discharged to home. The exact mechanisms of waterskiing-related ASDH are unclear; however, rotational acceleration of the brain might cause separation of the brain and the dura mater, with consequent rupture of the bridging veins. Moreover, a history of traumatic subarachnoid hemorrhage in the current case might have contributed to the development of ASDH after a relatively mild head trauma. Careful evaluation for the indication of endoscopic intervention and intracranial pressure monitoring following surgery are imperative for endoscopic evacuation in young patients with ASDH.

## 1. Introduction

To date, the majority of research has focused on waterskiing and has shown an association with multiple injury types, including contusions, abrasions, lacerations, fractures, strains, sprains, ruptured tympanic membranes, vaginal lacerations, enema injury, infections, cardiac trauma, and spinal cord damage [1]. However, there have been very few published cases detailing the specific nature of waterskiing-related traumatic brain injury [2,3]. We herein describe an unusual case of waterskiing-related acute subdural hematoma (ASDH) in an 18-year-old male who was successfully treated with endoscopic evacuation of the hematoma. The mechanisms that might have resulted in this type of injury and our approach to the treatment of ASDH are discussed.

## 2. Case report

An 18-year-old male sustained head injury while waterskiing and was referred to our hospital. He had a history of traumatic subarachnoid hemorrhage two years ago (Fig. 1). He was a novice waterskiier, who had four months of experience, wearing a life jacket but was not wearing a helmet. He stated that he lost balance and tumbled off the

board (Video 1), striking his occiput on the water surface at a slow speed of 27 km/h during a practice session of trick maneuvers. After the fall, which was fourth on the day, the patient sank out of sight in the water for a period of several seconds and floated with face up while breathing. One of the peers on a rescue boat jumped into the water and pulled the patient up to the boat, at which time he complained of headache and lost consciousness shortly after the rescue. The patient was comatose at the time of emergency medical service arrival at the scene. He was transferred immediately to our hospital by a helicopter with an emergency medical doctor on board, i.e., the doctor-helicopter.

On admission at 78 min after the accident, physical examination revealed no signs of external injury. His vital signs were stable, and his consciousness level improved to a Glasgow Coma Scale (GCS) score of 13 (E3V4M6). Neurological examination showed mild left hemiparesis. An initial computed tomography (CT) scan showed a left fronto-temporal ASDH, which was 10 mm in thickness, and a slight midline shift (Fig. 2A). There were no contusional hematomas or skull fractures observed. Although the second CT with contrast material performed an hour later did not demonstrate hematoma growth, development of contusional hematomas, or abnormal enhancement indicating active bleeding (Fig. 2B), his consciousness level deteriorated to a GCS score

\* Corresponding author at: Department of Neurosurgery, Akita Red Cross Hospital, 222-1 Nawashirosawa, Saruta, Kamikitate, Akita 010-1495, Japan.

E-mail address: [jun\\_maruya@akita-med.jrc.or.jp](mailto:jun_maruya@akita-med.jrc.or.jp) (J. Maruya).

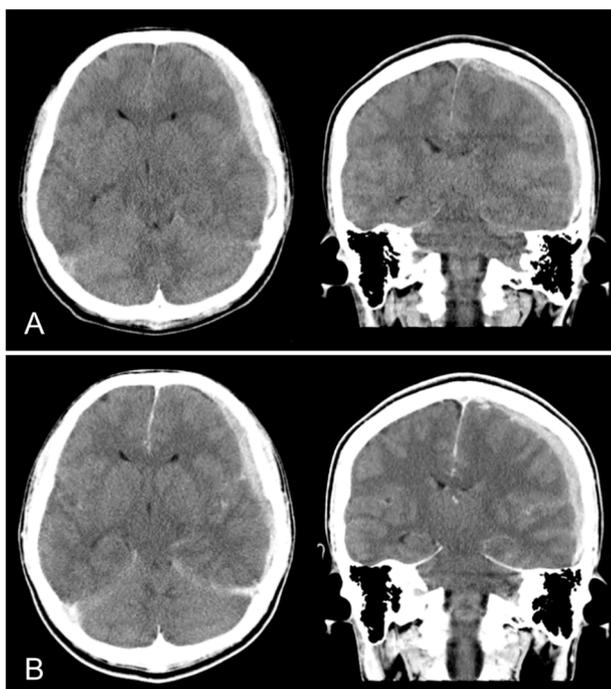
<https://doi.org/10.1016/j.inat.2019.100478>

Received 4 March 2019; Received in revised form 30 April 2019; Accepted 18 May 2019

2214-7519/© 2019 The Authors. Published by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).



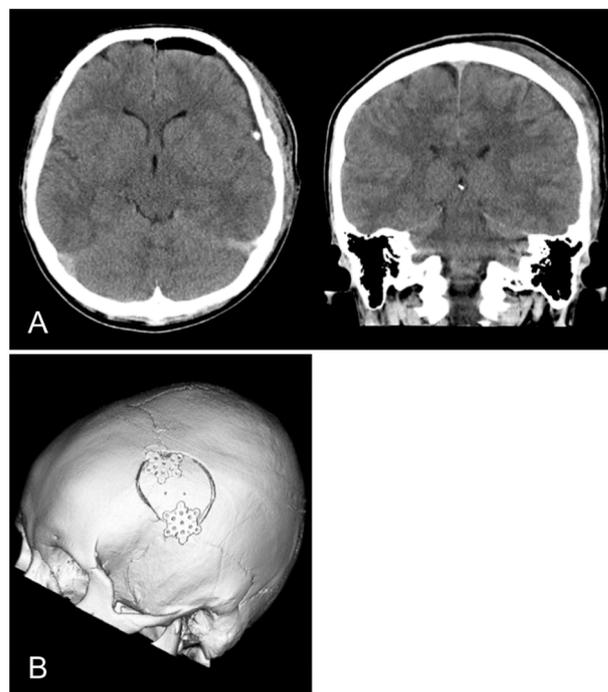
**Fig. 1.** Computed tomography (CT) scans obtained two years before the admission demonstrating a small traumatic subarachnoid hemorrhage in the left parietal lobe.



**Fig. 2.** Preoperative CT scans at the time of the current accident. (A) Initial CT scans revealing a left frontotemporal acute subdural hematoma, 10 mm in thickness, and a slight midline shift. No contusional hematomas or skull fractures are observed. (B) Follow-up CT scans with contrast material performed an hour later demonstrating the absence of hematoma growth, lack of contusional hematomas, and lack of abnormal enhancement to indicate active bleeding.

of 10 (E2V3M5). Therefore, surgical intervention was planned. The patient was less likely to require decompressive craniectomy because the impact of the head injury was not so severe, and the CT findings and clinical symptoms were also not so critical. We selected an endoscopic assisted hematoma evacuation after a small craniotomy, and intracranial pressure (ICP) monitoring following surgery was planned for potential decompressive craniotomy due to postoperative brain swelling.

A rapid intravenous infusion of mannitol was performed, which was immediately followed by transfer of the patient to the operating room and initiation of general anesthesia. A 6-cm sigmoid-shaped skin incision was made above the center of the site of ASDH, and a cranioplastic craniotomy, 45 mm in diameter, was performed. Simultaneously, the patient was prepared for potential decompressive craniectomy against acute brain swelling or uncontrollable bleeding. The dural tension was slack by tactile evaluation. After the dura was incised in a cruciate



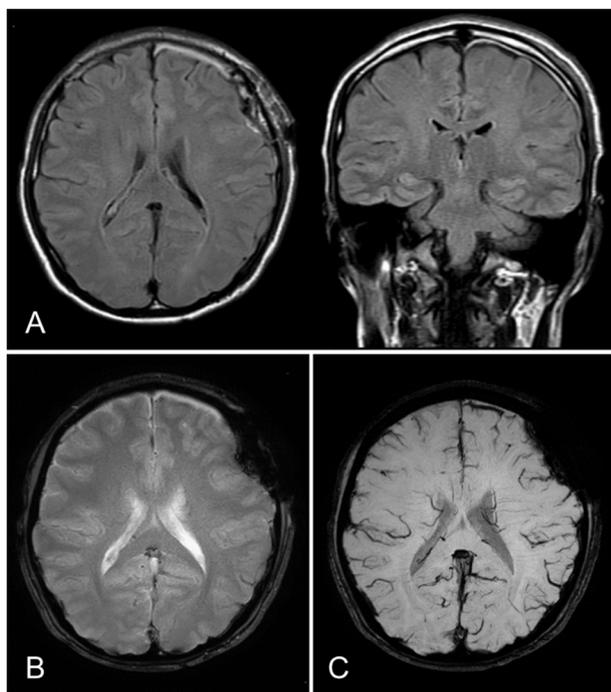
**Fig. 3.** Postoperative CT scans. (A) CT scans showing near-complete evacuation of the hematoma. (B) Three-dimensional CT showing the cranial bone after the procedure in which a small cranioplastic craniotomy, 45 mm in diameter, was performed.

fashion, the clot beneath the craniotomy was evacuated. Since adequate subdural spaces enough to manipulate the endoscope were confirmed, we finally decided to perform hematoma evacuation using the endoscope. Briefly, a rigid endoscope, 4 mm in diameter, with a zero-degree lens (Karl Storz Hopkins II, Tuttlingen, Germany) was introduced through the craniotomy, and a malleable suction cannula was used to evacuate the hematoma. The rigid endoscope was held by an assistant, whereas the suction cannula was held by the operator's left hand. The operator's right hand was used to manipulate the forceps or the brain retractor to create sufficient subdural working space. The hard clots near the apical bridging veins were not evacuated to avoid additional bleeding. There was no acute brain swelling, and active bleeding was not observed. The subdural space was copiously irrigated with artificial cerebrospinal fluid. After confirming complete hemostasis, a drainage tube and an ICP sensor were inserted in the subdural space, and the dura was closed. The bone flap was fixed with titanium plates, and the skin was closed with skin staples. The entire procedure was completed in approximately 1.5 h.

A postoperative CT scan showed near-complete evacuation of the hematoma (Fig. 3). The altered consciousness and mild left hemiparesis of the patient improved immediately. The average ICP remained below 10 mmHg, and the drainage tube and the ICP sensor were removed on postoperative day one. Magnetic resonance images obtained on postoperative day four did not reveal any cerebral contusions or diffuse axonal injury (Fig. 4). He was discharged to home on postoperative day ten with a modified Rankin scale score of zero.

### 3. Discussion

Waterskiing includes three disciplines, slalom, trick, and jump, and is associated with a significant danger of injuries or death [4]. Slalom is based on speed, rope length, and the skier's ability to turn six buoys in the slalom course. Trick consists of surface and wake tricks, including rotations, flips, and toeholds. Jump is performed on two skis over a six-foot ramp [5]. In an investigation of injuries occurring during



**Fig. 4.** Magnetic resonance images obtained on postoperative day four demonstrating the absence of cerebral contusions or diffuse axonal injury (A, fluid-attenuated inversion recovery image; B, T2\*-weighted gradient-echo image; C, susceptibility-weighted image).

competitive waterskiing, slalom skiers reported the most injuries (76.8%), with 23.2% of the injuries experienced during jump maneuvers and none during trick maneuvers [5]. According to a large national analysis of water sports-related injuries reported from 2001 to 2003, head injuries, which were the least frequently experienced type among waterskiers, were most common among wakeboarders, likely due to the high speed and complex acrobatic maneuvers involved in wakeboarding [1]. Lyons et al. reported that the average magnitude of acceleration of the head during low-speed waterskier falls was approximately 2–4 g [6]. Based on a recent report of a 50-g threshold for brain injuries, impacts of such magnitude pose minimal risk of serious injury [6]. Based on these findings, waterskiing-related head trauma, especially in low-speed trick maneuvers, which occurred in the current case, is extremely rare. To the best of our knowledge, there are only two published cases of waterskiing-related significant head trauma, including traumatic middle cerebral artery dissection with an ischemic stroke [2] and acute subdural hematoma [3]. The current patient sustained a blow to the occipital region of the head upon contact with the water surface, with a resultant ASDH. The exact mechanisms of waterskiing-related ASDH are not clear; however, rotational acceleration of the brain in the anteroposterior direction might cause separation of the brain and the dura mater, with consequent rupture of the bridging veins [7]. A history of head injury and post-concussion headache with a thin subdural hematoma is a strong risk factor for catastrophic ASDH in American football- and judo-related head injuries [8]. Therefore, the history of traumatic subarachnoid hemorrhage of the current patient might have contributed to the development of ASDH after a relatively mild head trauma. The mild ipsilateral hemiparesis might have been due to the Kernohan-Woltman notch phenomenon [9].

There are several potential explanations for the favorable recovery observed in the current case. First, wearing a life jacket, i.e., a flotation vest, prevented drowning and aspiration pneumonia in the event of loss of consciousness. Second, the peers had training on rescue and basic life-saving skills organized by the involved water sports association. Therefore, quick and appropriate rescue was performed at the scene.

Third, the patient was transferred to the emergency medical care center immediately by the doctor-helicopter, and the surgery was performed in a timely fashion. Finally, helmets should be advised to novice or young waterskiers, although it might impede the athletic performance.

Recently, several studies described the validity of rigid [10–17] and flexible [16,18] endoscopic evacuation of ASDH in elderly patients. The operating time with the rigid endoscope was generally shorter than that with the flexible endoscope [13,14,16–18], likely due to the better maneuverability and clear visualization. Conversely, flexible endoscope may be more useful in narrow or deep subdural spaces [16,18]. In initial clinical reports on the endoscopic evacuation of ASDH, most authors described freehand manipulation of the endoscope, with the endoscope in one hand and the suction cannula in the other hand [17]. However, recent studies emphasized that the manipulation performance of both hands of the operator was improved when the endoscope was held with a fixation device or by an assistant [12,16–18]. Since this approach allows the operator to use the suction cannula and a bipolar forceps simultaneously resulting in meticulous manipulation akin to that in microscopic neurosurgery [18], both hands manipulation can contribute to a secure evacuation [12], shortened operation times [16], and strict hemostasis [17]. Moreover, simultaneous use of the suction cannula and a brain retractor might contribute to an effective hematoma evacuation due to securing sufficient subdural working space in critical condition [16]. In an emergency situation, endoscopic evacuation following burr hole surgery may be an effective method [15,16].

Yokosuka et al. reported the following indications of endoscopic surgery for ASDH: (i) presence of symptoms; (ii) age older than 70 years; (iii) absence of moderate or massive brain contusion/hematoma; (iv) absence of an enlarging subdural hematoma; (v) patient not at high risk for bleeding [13]. Additionally, Karakhan et al. reported the following contraindications of endoscopic surgery: (i) widespread brain laceration; (ii) large bleeding vessels; (iii) brain prolapse; (iv) calcification of hematoma [19]. Therefore, nonelderly patients, e.g., younger than 65 years, moderate or massive cerebral contusions, and enlarging hematomas are generally not accepted as indications for endoscopic surgery [13,14]. In their report of a 31-year-old male with ASDH who was treated with endoscopic evacuation, Kuge et al. suggested that sufficient surgical space is one of the most important factors that should be considered during endoscopic surgery in young patients [15]. Because their patient had a long-term schizophrenia diagnosis and mild brain atrophy, there was enough surgical space for safe completion of the procedure [15]. To the best of our knowledge, the current patient is the first description of ASDH in a previously healthy 18-year-old male who was successfully treated with endoscopic assisted evacuation.

Emergency trephination has been widely accepted as an initial procedure for ASDH. Trephination is a quick and easy technique to reduce ICP by evacuating hematoma. However, hematoma evacuation may often result in partially and ICP reduction may be often temporary. Thus, emergency trephination should be followed by craniotomy or craniectomy [20]. However, if hematoma would be evacuated sufficiently by endoscopic surgery within low ICP after emergency trephination, the control of ICP may be easy and craniotomy or craniectomy may not be required potentially [16]. Selective endoscopic evacuation (SEE) for sufficiently low ICP patients following hematoma irrigation with trephination therapy (HITT), or the “HITT and SEE strategy” is not so invasive and may have an important advantage in the rapid completion of hematoma evacuation [16]. The simultaneous use of suction cannula and a brain retractor, a relatively large craniotomy (45 mm in diameter) compared with those created in other reports, and rapid intravenous infusion of mannitol might be very effective for securing sufficient subdural working space in the current patient. We insist that careful evaluation for the indication of endoscopic intervention and ICP monitoring following surgery [21] are critical for endoscopic evacuation in young patients with ASDH. Additional cases are required to evaluate the safety of endoscopic assisted surgery in young patients.

#### 4. Conclusion

Waterskiing-related traumatic brain injury, especially in low-speed trick maneuvers, is extremely rare. The exact mechanisms of waterskiing-related ASDH are still unclear; however, rotational acceleration of the brain might cause separation of the brain and the dura mater, with consequent rupture of the bridging veins and ASDH. Moreover, the past history of traumatic subarachnoid hemorrhage in the current case might have contributed to the development of ASDH after a relatively mild head trauma.

Waterskiing-related ASDH in an adolescent was successfully treated with endoscopic assisted hematoma evacuation. Careful evaluation for the indication of endoscopic intervention, and in addition, ICP monitoring following surgery are imperative for endoscopic assisted surgery in young patients with ASDH.

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.inat.2019.100478>.

#### Declaration of Competing Interest

Informed consent was obtained from the patient for publication of this case report. The authors declare that they have no financial or other conflicts of interest in relation to this research and its publication.

#### Acknowledgment

We would like to thank Dr. Tetsuya Nagayama (Atsuchi Neurosurgical Hospital, Kagoshima, Japan) for providing the CT images and information on the patient.

#### References

- [1] S.G. Hostetler, T.L. Hostetler, G.A. Smith, et al., Characteristics of water skiing-related and wakeboarding-related injuries treated in emergency departments in the United States, 2001–2003, *Am. J. Sports Med.* 33 (2005) 1065–1070.
- [2] T. Mizutani, H.I. Goldberg, J. Parr, et al., Cerebral dissecting aneurysm and intimal fibroelastic thickening of cerebral arteries. Case report, *J. Neurosurg.* 56 (1982) 571–576.
- [3] I. Takahashi, Y. Morishita, S. Nanzaki, et al., Successful emergency room treatment of acute subdural hematoma with burr hole surgery: a case report, *The Medical Journal of Teine Keijinkai Hospital* 5 (2002) 51–55 (In Japanese: English abstract).
- [4] G. Hummel, B.J. Gainor, Waterskiing-related injuries, *Am. J. Sports Med.* 10 (1982) 215–218.
- [5] S. Loughlin, Investigation of injuries occurring within competitive water-skiing in the UK, *International Journal of Exercise Science* 6 (2013) 29–42.
- [6] J.C. Lyons, M. Pollard, G. Goodman, et al., The severity of impacts during low-speed water skier falls, *Open Sports Med. J.* 6 (2012) 29–33.
- [7] Y. Mizobuchi, S. Nagahiro, A review of sport-related head injuries, *Korean Journal of Neurotrauma* 12 (2016) 1–5.
- [8] S. Nagahiro, Y. Mizobuchi, Current topics in sports-related head injuries: a review, *Neurol. Med. Chir.* 54 (2014) 878–886.
- [9] R. Carrasco, J.M. Pascual, M. Navas, et al., Kernohan-Woltman notch phenomenon caused by an acute subdural hematoma, *J. Clin. Neurosci.* 16 (2009) 1628–1631.
- [10] P.J. Codd, A.S. Venteicher, P.K. Agarwalla, et al., Endoscopic burr hole evacuation of an acute subdural hematoma, *J. Clin. Neurosci.* 20 (2013) 1751–1753.
- [11] H. Kon, A. Saito, H. Uchida, et al., Endoscopic surgery for traumatic acute subdural hematoma, *Case Report in Neurology* 5 (2013) 208–213.
- [12] T. Ueba, M. Yasuda, T. Inoue, Endoscopic burr hole surgery with a curettage and suction technique to treat traumatic subacute subdural hematomas, *Journal of Neurological Surgery Part A: Central European Neurosurgery* 76 (2015) 63–65.
- [13] K. Yokosuka, M. Uno, K. Matsumura, et al., Endoscopic hematoma evacuation for acute and subacute subdural hematoma in elderly patients, *J. Neurosurg.* 123 (2015) 1065–1069.
- [14] Miki K, Yoshioka T, Hirata Y, et al. Surgical outcome of acute and subacute subdural hematoma with endoscopic surgery. *No Shinkei Geka* 44: 455–462, 2916 (In Japanese: English abstract).
- [15] A. Kuge, D. Tsuchiya, S. Watanabe, et al., Endoscopic hematoma evacuation for acute subdural hematoma in a young patient: a case report, *Acute Medicine & Surgery* 4 (2017) 451–453.
- [16] J. Maruya, S. Tamura, R. Hasegawa, et al., Endoscopic hematoma evacuation following emergent burr hole surgery for acute subdural hematoma in critical conditions: technical note, *Interdisciplinary Neurosurgery* 12 (2018) 48–51.
- [17] H. Matsumoto, H. Minami, H. Hanayama, et al., Endoscopic hematoma evacuation for acute subdural hematoma in the elderly: a preliminary study, *Surg. Innov.* 25 (2018) 455–464.
- [18] T. Kawasaki, Y. Kurosaki, H. Fukuda, et al., Flexible endoscopically assisted evacuation of acute and subacute subdural hematoma through a small craniotomy: preliminary results, *Acta Neurochir.* 160 (2018) 241–248.
- [19] V.B. Karakhan, A.A. Khodnevich, Endoscopic surgery of traumatic intracranial haemorrhages, *Acta Neurochir. Suppl.* 61 (1994) 84–91.
- [20] H. Karibe, T. Hayashi, T. Hirano, et al., Surgical management of traumatic acute subdural hematoma in adults: a review, *Neurol. Med. Chir.* 54 (2014) 887–894.
- [21] H. Koizumi, E. Suehiro, Y. Fujiyama, et al., Update on intensive neuromonitoring for patients with traumatic brain injury: a review of the literature and the current situation, *Neurol. Med. Chir.* 54 (2014) 870–877.