MATERIALS AND METHODS

A computerized search of the National Library of Medicine (PubMed) database of the up-to-date literature (published from 2010 to 2014) was undertaken. The medical subject headings “chronic subdural hematoma” combined with “causality” yield 197 citations (excluded non-English language and non-human citations). The abstracts of relevant citations were reviewed and 41 articles were selected. The selected papers have been categorized into one of five categories by the causalities proposed by the authors (Table 1). By a review of literature, the author suggested a different view on the causation of CSH.

RESULTS

As the cause of CSH, sufficient subdural space was alluded in 19 papers, coagulopathy in 13 papers, and trauma in 8 papers, including the combined categories. Sufficient subdural space included arachnoid cyst, cerebrospinal fluid leak, lumbar drainage, spinal anesthesia, intracranial hypotension, hydrocephalus, and other factors.

INTRODUCTION

Chronic subdural hematomas (CSHs) are generally regarded to be a traumatic lesion. It was regarded as a stroke in 17th century, an inflammatory disease in 19th century. From 20th century, it became a traumatic lesion. CSH frequently occur after a trauma, however, it cannot occur when there is no enough subdural space even after a severe head injury. CSH may occur without trauma, when there is sufficient subdural space. The author tried to investigate trends in the causation of CSH. By a review of literature, the author suggested a different view on the causation of CSH. CSH usually originated from either a subdural hygroma or an acute subdural hematoma. Development of CSH starts from the separation of the dural border cell (DBC) layer, which induces proliferation of DBCs with production of neomembrane. Capillaries will follow along the neomembrane. Hemorrhage would occur into the subdural fluid either by tearing of bridge veins or repeated microhemorrhage from the neomembrane. That is the mechanism of hematoma enlargement. Trauma or bleeding tendency may precipitate development of CSH, however, it cannot lead CSH, if there is no sufficient subdural space. The key determinant for development of CSH is a sufficient subdural space, in other words, brain atrophy. The most common and universal cause of brain atrophy is the aging. Modifying Virchow’s description, CSH is sometimes traumatic, but most often caused by degeneration of the brain. Now, it is reasonable that degeneration of brain might play pivotal role in development of CSH in the aged persons.

Key Words: Hematoma subdural chronic · Causality · Classification · Aging · Intracranial pressure · Craniocerebral trauma.

Materials and methods

A computerized search of the National Library of Medicine (PubMed) database of the up-to-date literature (published from 2010 to 2014) was undertaken. The medical subject headings “chronic subdural hematoma” combined with “causality” yielded 197 citations (excluded non-English language and non-human citations). The abstracts of relevant citations were reviewed and 41 articles were selected. The selected papers have been categorized into one of five categories by the causalities proposed by the authors (Table 1). By a review of literature, the author suggested a different view on the causation of CSH.
cerebral atrophy, and the old age. Coagulopathy included factor X deficiency, factor XIII deficiency, von Willebrand’s disease, a fibrinogenemia, anticoagulant therapy, and end stage renal disease. Trauma included head-banging, dancing, and any tears in the arachnoid membrane following contusion of the brain or slight bleeding from a bridging vein. Combined category included trauma with coagulopathy or sufficient subdural space with coagulopathy. Others included dural metastasis, lymphoma, infection, antiviral therapy, and birth related complications.

**DISCUSSION**

Sufficient subdural space was the most commonly alluded as the cause of CSH. The number of papers did not have a value by itself, since papers did not have equal frequency or importance. However, it may represent relative importance or proportion of certain factors. Recent papers may not represent the whole aspects of the causation. They may have a tendency to publish atypical cases. However, we can explore this curious lesion using the more updated knowledge.

Traditional model of causation, so-called the classic epidemiologic triangle of host, agent, and environment was not suitable for CSH. To evaluate relative importance in multiple causation, web of causation model with directed acyclic graph (Fig. 1) is more suitable. Development of CSH starts from the separation of the dural border cell (DBC) layer, which can occur either by trauma or low intracranial pressure. Severe trauma cannot produce a CSH even in a patient with coagulopathy, when the subdural space is not enough. Trauma cannot be the causality of CSH in this situation. Furthermore, CSH may occur without trauma. Causation implies that there is a true mechanism that leads from exposure to disease. Trauma or bleeding tendency is frequently associated with CSH and they may precipitate development of CSH, however, it cannot lead CSH, if there is no pre-requisite. The key determinant for development of CSH is a sufficient subdural space, in other words, cerebral atrophy. The most common and universal cause of cerebral atrophy is the aging. If we classify a disease according to the key determinant, cerebral atrophy is responsible for the CSH instead of trauma.

Trauma was so frequently observed that CSH might be a traumatic lesion. The majority of CSHs are suspected by an undiagnosed trivial head injury. This assumption is hard to ex-

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**Table 1. Causality of chronic subdural hematomas in selected papers (2010–2014)**

| Category       | Authors (year)                                                                 |
|----------------|--------------------------------------------------------------------------------|
| Coagulopathy   | Kawano et al. (2013)\(^{59}\), Sakai et al. (2013)\(^{59}\), Vuk et al. (2010)\(^{76}\), De Bonis et al. (2013)\(^{36}\), Ledić et al. (2014)\(^{59}\), Wang et al. (2013)\(^{48}\), Senturk et al. (2010)\(^{59}\), Bosche et al. (2012)\(^{59}\), Luongo et al. (2012)\(^{59}\) |
| Sufficient SS  | Zeng et al. (2011)\(^{59}\), Kertmen et al. (2012)\(^{59}\), Takayasu et al. (2012)\(^{59}\), Lohani et al. (2013)\(^{59}\), Kwak et al. (2013)\(^{59}\), Edmondson et al. (2014)\(^{59}\), Yang et al. (2012)\(^{59}\), Beck et al. (2014)\(^{59}\), Yoshida et al. (2014)\(^{59}\), Ikegami et al. (2012)\(^{59}\), Ferrante et al. (2010)\(^{59}\), Schievink (2013)\(^{59}\), Tan and Liew (2013)\(^{59}\), Inamasu et al. (2013)\(^{59}\), Amorim et al. (2010)\(^{59}\), Ohno et al. (2013)\(^{59}\), Tseng et al. (2014)\(^{59}\) |
| Trauma         | Pirayesh Islamian et al. (2014)\(^{59}\), Tanaka and Ohno (2013)\(^{77}\), Berger et al. (2012)\(^{59}\), Sousa et al. (2013)\(^{59}\), De Carvalho et al. (2013)\(^{59}\) |
| Combined       | Reichman et al. (2012)\(^{59}\), Aspegren et al. (2013)\(^{59}\), Hagihara et al. (2010)\(^{59}\), Schievink et al. (2010)\(^{59}\) |
| Others         | Kuan-Yin et al. (2013)\(^{59}\), Prasad et al. (2013)\(^{59}\), Barrios et al. (2014)\(^{59}\), Goto et al. (2013)\(^{59}\), Gabaeff (2013)\(^{59}\), Eljebbouri et al. (2013)\(^{59}\) |

**Fig. 1.** Schematic representation of the web of causation model for causation of chronic subdural hematoma. Development of CSH starts from the separation of the dural border cell (DBC) layer. Trauma or bleeding tendency may precipitate hematoma formation, however, it cannot produce chronic subdural hematoma, when there is no potential subdural space. The real lines mean direct causal relationships, while the dotted lines represent precipitations. Adopted from Lee KS et al.\(^{59}\), with permission from BJ Neurosurg.
plain why CSH is rare in the young with severe head injury, while the majority of CSH occur in the old even without trauma\textsuperscript{39}. In patients without trauma history, we presumed that they forgot the trauma, since the CSH is common in the aged and alcoholic. However, there are numerous cases of CSHs without trauma\textsuperscript{3}.

CONCLUSION

The origin of a CSH is multiple. It can be developed spontaneously, or changed from a subdural hygroma or an acute subdural hematoma. A more important prerequisite is sufficient potential subdural space that is aging, degeneration of the brain. CSH was a stroke in 17th century\textsuperscript{37}, an inflammation in 19th century, and it became a traumatic lesion in 20th century\textsuperscript{31}. Virchow recognized that hematoma durae matris sometimes was traumatic, but he believed that this lesion was most often caused by chronic inflammation (pachymeningitis chronica hemorrhagica) of the dura\textsuperscript{3,32,33}. Modifying Virchow’s description, CSH is sometimes traumatic, but most often caused by degeneration of the brain. Now, it would be reasonable that in the aged persons, degeneration of brain might play the most important role in development of CSH.

Fig. 2. Schematic explanation for the difference in the incidence of chronic subdural hematoma. Anatomical difference of the cranium may influence the left and male prevalence of chronic subdural hematoma. The length and degree of atrophy in this figure are not actual data.

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