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Mortality of older patients with dementia after surgery for chronic subdural hematoma: a nationwide study

ABSTRACT

BACKGROUND: Dementia is associated with an excess risk of death but mortality after chronic subdural hematoma (CSDH) evacuation in elderly with dementia is unknown. We assessed the association between dementia and one-year case-fatality in elderly persons undergoing CSDH evacuation.

METHODS: We conducted a nationwide Finnish cohort study including all elderly persons (≥ 60 years) undergoing CSDH evacuation during 1997-2014 (referred to as cases). We identified controls, without a diagnosis of CSDH, that were matched for age, sex and year of first hospitalization with a new dementia diagnosis. We identified cases and controls with a pre-existing diagnosis of dementia. Outcome was 12-month mortality. Mortality was compared in case-only and case-control analyses.

RESULTS: Of 7,621 included cases, 885 (12%) had a pre-existing diagnosis of dementia. The proportion of cases increased from 9.7% in 1997-2002 to 12.2% in 2012-2014 ($p=0.038$ for trend). In the case-analysis, dementia independently associated with one-year case-fatality (dementia vs. no dementia odds ratio [OR] 1.50, 95% confidence interval [CI] 1.26–1.78). Sensitivity analysis suggested the association to be strongest for those 60-69 years old (OR 3.21, 95% CI 1.59–6.47). In the case-control matched analysis, one-year mortality was 26% in the dementia CSDH surgery group compared to 16% in dementia non-CSDH controls ($p<0.001$).

CONCLUSIONS: Dementia is a significant risk factor for one-year mortality after CSDH surgery in the elderly. The proportion of elderly CSDH patients having a pre-existing diagnosis of dementia is increasing. Thus, there is a need for improved evidence regarding the indications and benefits of CSDH evacuation among elderly persons.

KEYWORDS: chronic subdural hematoma, dementia, mortality, nationwide study, neurosurgery

INTRODUCTION

Chronic subdural hematoma (CSDH) has become one of the most common neurosurgical disorders, mainly due to the ageing population with an increased risk for falls and the concomitant increased use of antithrombotic medication [1,2,3]. In case of a CSDH causing symptoms and neurological signs, surgery is the treatment of choice [4]. The ageing population is the key factor behind the increasing number of people with dementia [5]. The global incidence of dementia has been estimated to be 4.2/100,000 for those ≥ 65 years [6]. Further, it has been estimated that the prevalence of dementia will triple by 2050 [5], despite some evidence that the incidence of dementia may not be increasing, especially in high-income countries [7,8]. Still, dementia is rapidly growing into a major contributor to demand for healthcare with associated costs and increased disability [9]. This is also reflected in neurosurgical practice, where patients with disorders such as acute traumatic brain injury [10], glioblastoma [11], degenerative cervical spine disease [12], and CSDH [13] are getting older and older, partly due to the ageing trends but also because of the ability of modern medicine to treat the frailer elderly successfully. Among persons ≥ 65 years, the CSDH incidence has been described to be between 29-64 per 100,000 [13,14,15].

The rationale for surgical evacuation of CSDH is alleviation of symptoms caused by the mass effect of the CSDH. In most surgical procedures, the benefit-risk ratio decreases among older patients [16]. Although, CSDH evacuation is considered a minor intervention, one-year mortality among the elderly with CSDH has been reported to be as high as 32% [17]. Although the procedure may not be that invasive, the high mortality probably reflects high age, comorbidities and frailty [17,18,19]. Thus, CSDH may be a late manifestation of these factors ultimately leading to death.

Currently, there are few studies looking at elderly patients treated for CSDH, but no studies looking specifically at the relationship between age, dementia and outcome after CSDH surgery. To address this unmet demand, we aimed to assess the occurrence of CSDH evacuation in elderly patients and to assess one-year case-fatality after CSDH evacuation in patients with and without a pre-existing diagnosis of dementia. We hypothesized that the proportion of patients with a pre-existing diagnosis of dementia undergoing CSDH evacuation had increased and that one-year case-fatality would be markedly higher in this patient group. Furthermore, we hypothesized that one-year case-fatality would be higher in patients with dementia undergoing CSDH evacuation compared to matched controls with dementia but without a diagnosis of CSDH.

METHODS

Study design

We used the nationwide Finnish Care Register for Health Care, which we have described previously in detail [20]. (**Appendix 1**)

Case definition

We defined cases as elderly adults (≥ 60 years) with a new event of CSDH evacuation between 1 January 1997 and 31 December 2014 (**Figure 1**). (**Appendix 1**)

Definition of exposure

We defined exposure as having a pre-existing diagnosis of dementia. Thus, “exposed cases” are defined as persons undergoing CSDH evacuation with a pre-existing diagnosis of dementia, while “non-exposed cases” are defined as persons undergoing CSDH evacuation but without a diagnosis of dementia. (**Appendix 1**)

Exposed controls

We defined exposed controls as persons with a diagnosis of dementia without a history of hospitalization due to head injury. We matched every exposed case with four exposed controls based on age, sex and year of first hospitalization with a new dementia diagnosis. (**Appendix 1**)

Definition of outcome

The study population was followed up from time of operation until death or end of follow-up on 31 December 2017, based on vital status data from the Population Register Centre. We defined all-cause one-year mortality as the outcome of interest.

Statistical analyses (Appendix 1)

Ethical Statement (Appendix 1)

RESULTS

The study population consisted of 7,621 cases and 2,633 controls. There were 885 exposed cases and 6,736 non-exposed cases (**Figure 1**). Overall median age was 77 years (IQR 70, 83) and 34% were female. The vast majority of all CSDH evacuations (89%) were performed in a University hospital. One in five of the cases underwent a second CSDH evacuation within one-year of the primary operation. During the study period median age increased (76 years to 78 years) and fewer operations were carried out in non-University Central hospitals (from 19% to 5%) (**Appendix 2**).

Total follow-up time from the first CSDH evacuation to death or end of 2017 was 43,210 patient-years. Median follow-up was 4.8 years (IQR 2.2-8.2 years). During the whole follow-up, 4,916 out of 7,621 cases died (65%). Of exposed cases, 88% died during the follow-up, compared to 61% of non-exposed cases ($p<0.001$).

Overall one-year case-fatality was 16%. Cases dying within one-year of CSDH evacuation were older (median age 82 vs. 76 years), more often treated in a non-University Central hospital (13% vs. 10%) than in a University hospital, underwent fewer re-evacuations (15% vs. 21%), and had more often a diagnosis of dementia (19% vs. 10%) compared to cases not dying within one-year (**Table 1**).

Totally 885 cases (12%) had a pre-existing diagnosis of dementia or received the diagnosis within one-year of the primary CSDH evacuation (exposed cases). These exposed cases were older (median age 82 years vs. 76 years), more often female (48% vs. 33%), more often operated in a central hospital (13% vs. 10%) and underwent fewer CSDH re-operations (17% vs. 20%) compared to non-exposed cases (**Table 2**). One-year

case-fatality was significantly higher in exposed cases compared to non-exposed cases (26% vs. 15%, $p<0.001$).

Hospital-based occurrence

The occurrence of CSDH evacuation among all age-groups (≥ 60 years) was 35.4 per 100,000. The occurrence of CSDH evacuation increased from 29.7/100,000 in 1997-2002 to 42.7/100,000 in 2012-2014. The occurrence of CSDH evacuation increased especially among those 80-89 years (from 60.4/100,000 in 1997-2002 to 95.8/100,000 in 2012-2014) and those 90 years or older (from 58.8/100,000 in 1997-2002 to 111/100,000 in 2012-2014). The proportion of exposed cases increased from 9.7% in 1997-2002 to 12.2% in 2012-2014 (p for trend=0.038) (**Figure 2**).

Case-only analysis

Including all cases, exposure to dementia was associated with an increased risk of one-year case-fatality with an OR of 1.50 (95% CI 1.26-1.78, $p<0.001$) (**Table 3**). Female sex (OR 0.81, 95% CI 0.71-0.92), CSDH re-operation within one-year (OR 0.67, 95% CI 0.56-0.79) and a more recent study year significantly associated with a reduced risk of one-year case-fatality, while higher age (OR 1.08, 95% CI 1.06-1.08) associated with an increased risk of one-year case-fatality (**Appendix 3**).

Exposure to dementia was associated with the highest risk of death among cases aged 60-69 years (OR 3.21, 95% CI 1.59-6.47, $p=0.001$) (**Table 3**). This association weakened with age, such that there were no association between exposure to dementia and risk of one-year case-fatality after CSDH evacuation for persons ≥ 90 years (OR 1.20, $p=0.47$).

The exposure of dementia was associated with one-year case-fatality with an HR of 1.38 (95% 1.20-1.60, $p<0.001$) in the Cox proportional Hazards model (adjusting for age, sex, hospital level of care, re-operation and primary operation year).

Exposed case-control analysis

For the 885 exposed cases, we identified 832 (94%) sets with at least one age, sex, and year of first hospitalization with a new dementia diagnosis matched exposed control. In detail, 585 out of 832 exposed cases (70%) had four exposed controls, 143 out of 832 exposed cases (17%) had three exposed controls, 60 out of 832 exposed cases (7%) had two exposed controls and 44 out of 832 exposed cases (5%) had one exposed control. Thus, there were 2,933 exposed controls in total.

One-year mortality was 26% ($n=216/832$) in the exposed case group compared to 16% ($n=459/2,933$) in the exposed control group ($p<0.001$).

DISCUSSION

Key findings

In this nationwide study, we show for the first time that dementia is an independent risk factor for one-year mortality in elderly patients undergoing CSDH evacuation. The association between dementia and mortality was strongest for those aged 60-69 years. Further, in the case-control analysis, we showed that patients with dementia undergoing CSDH evacuation had a significantly higher risk of death compared to those with dementia but without a diagnosis of CSDH. Also, during the study period, the occurrence of CSDH evacuation for those ≥ 60 years increased by 44% and the increase was especially evident in those 80-89 years and those ≥ 90 years, where the occurrence of CSDH increased by 59% and 89%, respectively. Furthermore, there was a significant trend towards a higher proportion of patients undergoing CSDH evacuation having a pre-existing diagnosis of dementia. Interestingly, female sex was associated with a lower one-year case-fatality. It is possible that this reflects sex-related differences in comorbidities and life-expectancy, rather than true sex-related differences.

Comparison of the findings to previous studies

Very few studies have assessed the relationship between dementia and outcome after CSDH evacuation. For example, Abe and colleagues did not find any association between dementia and poor post-operative functional outcome [23]. Still, there are studies looking at outcome after surgical treatment of elderly CSDH patients. Some studies have shown higher mortality and morbidity rates in elderly patients compared to young patients [17,19,24,25,26]. Several studies, however, found no independent association between age and outcome in elderly CSDH patients [27,28,29].

In our study, we assessed a longer-term mortality rate, one-year after surgery, and the difference in mortality rates between dementia and non-dementia CSDH patients was significant. The one-year mortality of CSDH patients with dementia (26%) is comparable to overall one-year mortality of elderly hip fracture patients (27%) [30]. Both hip fracture and CSDH may be considered sentinel health events and markers of a decline in health of elderly patients [31,32]. Further, dementia in itself is considered a malignant disorder with excess risk of death [33,34,35]. Thus, it is not surprising that dementia is associated with an increased mortality in CSDH patients. Furthermore, the case-control analysis showed that dementia patients undergoing CSDH surgery had a significantly higher one-year mortality than dementia patients without CSDH. It is possible that symptomatic CSDHs may aggravate and unmask other underlying significant medical conditions that may increase risk of death as well, partly explaining the higher mortality rate [17]. Another factor possibly explaining the higher mortality rate among dementia patients is delay in diagnosis. Delay in diagnosis and, thus, poorer functional status at admission is known to associate with poor outcome and mortality after CSDH surgery [36].

The increase in the proportion of patients with comorbid dementia undergoing CSDH surgery is in line with a recent study by Rauhala and colleagues. They reported the proportion of patients with dementia and CSDH increasing from 3% in 1990-1995 to 13% in 2011-2015 [13], although these results should be cautiously compared with ours as their study included adult patients of all ages and even conservatively treated patients.

Strengths and limitations

This is the first nationwide hospital-based study looking into the association between dementia and mortality after CSDH evacuation. The nationwide coverage using high-

quality and validated registers strengthens the findings [37,38]. A strength of this study is the employment of a matched case-control group, which enables comparison in mortality rates between dementia patients with and without CSDH. For 94% of patients, we were able to obtain at least one control case, and the number of cases and controls included in the study reached 10,554 in total. Another strength is that the study was conducted in a country where the social welfare and health care system is tax-funded and personal insurance status and socioeconomic factors do not impact availability, method or quality of treatment. Accordingly, our analysis provides a comprehensive view of the whole hospitalized patient population in Finland.

There are some limitations that should be mentioned. All large-scaled register-based studies include to a degree some diagnostic inaccuracies, coding errors and confounding factors that cannot be controlled for. Further, the most obvious limitation of any large-scaled register-based study is that we cannot draw any causative relationships but only assess associations. For example, we cannot exclude differences in other pre-existing comorbidities or functional capacity between CSDH cases with and without dementia that may explain differences in mortality. Likewise, a similar possibility of confounding applies to the case-control matching. However, the nationwide coverage and the large study group size decrease the risk of such confounding.

The Care Register for Health Care includes only hospitalized patients with a discharge diagnosis including dementia, which makes it plausible that we have missed patients diagnosed and treated in the outpatient setting [20]. For example, in clinical practice, an ICD diagnosis is not always registered for dementia patients and the disease might only be mentioned in their medical charts. Thus, these cases remain unrecognized when

searching for dementia diagnoses in the Care Register for Health Care and, thus, dementia is probably more frequent than recorded in the present study. For example, in our retrospective study approximately one in five patients undergoing CSDH evacuation had a diagnosis or a mention of dementia or memory impairment in their medical charts [39]. However, although the non-exposed cases (non-dementia) group may include patients with dementia, the mortality in exposed cases group was still significantly higher.

Moreover, we dichotomized patients into having a diagnosis of dementia or not without being able to account for severity. However, in the case-control analysis, one of the matching criteria was time since diagnosis. Still, the control group, as well, represents a cohort of patients being hospitalized for some reason (other than head injury) and having a discharge diagnosis including dementia. Yet, this is probably why the control group serves as a suitable control group for the CSDH evacuated cases, as both groups had all been hospitalized before. Further, changes in the diagnostic criteria also possibly affect our results and thus the increased proportion of dementia patients undergoing CSDH evacuation may partly be explained by changes in dementia diagnostics that have occurred [40].

Future directions

Dementia among CSDH patients is still a relatively uncommon entity. For example, in 2014 there were only 72 patients with pre-existing ICD-10 dementia diagnosis undergoing CSDH evacuation in Finland. However, 14,500 persons over the age of 64 years are annually diagnosed with dementia in Finland [41], and the world-wide prevalence of dementia is estimated to steadily increase [5]. At the same time, supposing that the incidence of CSDH continues to increase, we can expect the number of patients with

dementia undergoing CSDH evacuation to rise in the future. Although mortality rates are high, the surgery seems to be indicated in order to treat neurological symptoms, improve quality of life and alleviate care intensity. It is worth mentioning that in Finland, CSDH evacuation is almost entirely performed by burr-hole craniostomies in local anesthesia, avoiding the possible complications associated with general anesthesia [42,43]. This is especially relevant for elderly patients often having multiple comorbidities, which can predispose to complications in general anesthesia. Still, there is a need for studies in order to optimize treatment of CSDH for elderly patients with dementia.

CONCLUSION

The proportion of elderly CSDH patients having a pre-existing diagnosis of dementia is increasing. Dementia is an independent significant risk factor for one-year case-fatality after CSDH evacuation in the elderly, especially among men. The occurrence of CSDH surgery in elderly patients may be considered as marker of decline in general health with an associated excess risk of death. However, CSDH evacuation might be indicated to improve quality of life in elderly patients with dementia. Still, there is a need for improved evidence regarding the indications and benefits of CSDH evacuation among elderly persons with and without dementia.

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Table 1: Baseline characteristics for cases with a fatal and non-fatal one-year outcome

Variable	All cases (n=7,621)	Survivors (N=6,381)	Non-survivors (N=1,240)	p-value
Age, median (IQR)	77 (70-83)	76 (70-72)	82 (75-86)	<0.001
60-69	1,738 (23%)	1,595 (25%)	143 (12%)	<0.001
70-79	2,896 (38%)	2,537 (40%)	359 (29%)	
80-89	2,558 (34%)	1,970 (31%)	588 (47%)	
90+	429 (5%)	279 (4%)	150 (12%)	
Sex				
Female	2,611 (34%)	2,172 (34%)	439 (35%)	0.35
Male	5,010 (66%)	4,209 (66%)	801 (65%)	
Hospital level				
University hospital	6,807 (89%)	5,725 (90%)	1,082 (87%)	0.010
Central hospital	814 (11%)	654 (10%)	158 (13%)	
Primary operation year (quartiles)				
1997-2002	1,839 (24%)	1,516 (24%)	323 (25%)	0.23
2003-2007	1,921 (25%)	1,616 (25%)	305 (25%)	
2008-2011	2,020 (27%)	1,713 (27%)	307 (25%)	
2012-2014	1,841 (24%)	1,536 (24%)	305 (25%)	
Re-operation ^a	1,526 (20%)	1,336 (21%)	190 (15%)	<0.001
Dementia ^b	885 (12%)	654 (10%)	231 (19%)	<0.001
^a Re-evacuation of a chronic subdural hematoma within 1 year of the primary evacuation				
^b Dementia diagnosis before or within one-year of the chronic subdural hematoma evacuation				

Table 2: Baseline characteristics for cases exposed and not exposed to dementia

Variable	Dementia (n=885)	No dementia (n=6,736)	p-value
Age, median (IQR)	82 (78-86)	76 (69-82)	<0.001
60-69	53 (6%)	1,685 (25%)	<0.001
70-79	239 (27%)	1,657 (39%)	
80-89	494 (56%)	2,064 (31%)	
90+	99 (11%)	330 (5%)	
Sex			
Female	425 (48%)	2,186 (33%)	<0.001
Male	460 (52%)	4,550 (68%)	
Hospital level			
University hospital	766 (87%)	6,041 (90%)	0.005
Central hospital	119 (13%)	695 (10%)	
Primary operation year (quartiles)			
1997-2002	179 (20%)	1,660 (25%)	0.036
2003-2007	239 (27%)	1,681 (25%)	
2008-2011	242 (27%)	1,778 (26%)	
2012-2014	225 (26%)	1,616 (24%)	
Re-operation ^a	154 (17%)	1,372 (20%)	0.038
One-year mortality	231 (26%)	1,009 (15%)	<0.001

^aRe-evacuation of a chronic subdural hematoma within 1 year of the primary evacuation

Table 3: Case-mix adjusted association between exposure (dementia) and one-year case-fatality among cases

Group	OR (95% CI)	p-value
All patients	1.50 (1.26-1.78)	<0.001
60-69 years	3.21 (1.59-6.47)	0.001
70-79 years	1.77 (1.26-2.50)	0.001
80-89 years	1.39 (1.11-1.75)	0.004
90+ years	1.20 (0.73-1.96)	0.47
Note: Logistic regression analyses adjusted for age, sex, year of primary operation, re-operation and hospital level of care. Abbreviations: OR: Odds Ratio; CI: Confidence Interval		

FIGURE LEGENDS

Figure 1: Flow chart. *Abbreviations: ICD=International Statistical Classification of Diseases and Related Health Problems, NCSP-F=NOMESCO Classification of Surgical Procedures Finland, AAD10=Evacuation of chronic subdural hematoma, CSDH=Chronic Subdural Hematoma.*

Figure 2: Left: Hospitalization-based occurrence rates (per 100,000 persons) of chronic subdural hematoma evacuation in Finland. The population at risk includes the whole Finnish population in the specific age-band. Right: Proportion of patients undergoing CSDH surgery with a pre-existing diagnosis of dementia. The proportion increased from 9.7% in 1997 to 12.2% in 2012-2014.

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Supplementary data

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Appendix 1: Supplementary text

Appendix 2: Table 4

Appendix 3: Table 5

Appendix 4: Full list of references

Appendix 1: Supplementary text

METHODS

Study design

In summary, the Finnish Care Register for Health Care database is upheld by the National Institute for Health and Welfare in Finland and contains data on every person treated in all hospitals in Finland from 1969 onwards. Intracranial procedures are exclusively performed in selected tax-funded public hospitals - primarily the five University Central Hospitals and the network of tertiary, regional Central hospitals. Thus, the database comprehensively includes patients hospitalised for CSDH evacuation.

Case definition

We defined CSDH evacuation as an International Statistical Classification of Diseases and Related Health Problems (ICD) 10 diagnosis of S06.5 or I62.0 (ICD-9 has been in use in Finland during 1987-1995 and ICD-10 has been in use in Finland since 1996) with a combined NOMESCO Classification of Surgical Procedures Finland (NCSP-F) of AAD10 ("evacuation of chronic subdural hematoma", NCSP-F has been in use in Finland since 1997). Thus, a "case" is defined as the combination of an S06.5 or I62.0 ICD-10 diagnosis and an AAD10 NCSP-F code.

Definition of exposure

From the Care Register for Health Care, we identified all persons that had been hospitalised, for any reason, with a new diagnosis of dementia (ICD-9: 290, 331, 791; ICD-10: G30, F00, F01, F02, F03) between 1 January 1987 and 31 December 2014. We defined the admission date for the hospitalisation with the new dementia diagnosis as the date of diagnosis. We defined cases as having a pre-existing diagnosis of dementia if the

time of dementia diagnosis was before or within 1-year of CSDH evacuation. We chose the 1-year post-surgery time as hospitalisation due to trauma or impaired general condition may be the first signs of dementia leading to the diagnosis. The diagnoses of dementia in the Care Register for Health Care have been shown to be very accurate [21].

Exposed controls

Through the Care Register for Health Care search (see above), we identified persons hospitalised due to any reason with a primary or a secondary discharge diagnosis of dementia during 1987-2014 (ICD-9: 290, 331, 797; ICD-10: G30, F00, F01, F02, F03), and without a head injury diagnosis (ICD-9: 850-854, ICD-10 S06.X). We used a four to one matching ratio in order to adjust for mortality among the exposed controls between the date of exposure (dementia diagnosis) and time of CSDH evacuation, and to provide adequate statistical power for the analysis. We did not include the case-control sets if all four exposed controls had died before the exposed case underwent CSDH evacuation. Thus, if the exposed case had at least one exposed control alive at the time of CSDH surgery, a matched analysis was enabled.

Statistical analyses

We present descriptive characteristics as categorical or continuous data. We tested continuous variables for skewness and found them to be skewed. Thus, continuous variables are reported as medians with interquartile ranges (IQR). We compared categorical data between groups using a two-sided χ^2 test, adjusted for the Bonferroni correction when appropriate. We compared continuous data between groups using a non-parametric Mann-Whitney U or a Kruskal-Wallis H test. For the time-trend analyses, we

divided the patients into equally quartiles based upon year of treatment (1997-2002, 2003-2007, 2008-2011, 2012-2014).

We calculated hospital-based occurrence rates (per 100,000 persons) for CSDH evacuation. The hospital-based occurrence rates were calculated separately in the following age-groups: 60-69, 70-79, 80-89 and 90+, without age-adjustment within age-bands. The age-band specific occurrence calculation was based upon the whole Finnish population (<http://sotkanet.fi>). We further assessed trends in proportion of exposed cases during the study period and assessed trend statistics by the Jonckheere-Terpsta test.

In the primary case-only analysis, we used binary logistic regression, adjusting for variables that significantly differed ($p < 0.05$) between dementia and non-dementia patients and 1-year survivors and non-survivors in univariate analyses. We further tested the association between dementia and mortality separately in the pre-defined age-groups (60-69, 70-79, 80-89, 90+), adjusting for the same covariates. We also used Cox proportional Hazards models to estimate hazard ratio (HR), with 95% confidence intervals (CI) for 1-year mortality. We derived log-log plots of survival curves to verify that the proportional hazards assumption was not violated. In the exposed case-control analysis, we compared 1-year mortality between cases and controls using a χ^2 test.

We conducted the study according to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement [22].

Ethical Statement

The National Institute for Health and Welfare (THL/1326/5.05.00/2015) approved of the study and waived the need for patient consent, in accordance with Finnish national legislation. Statistics Finland (Dnro TK-53-1179- 16) and the Population Register Centre (Dnro 1873/410/16) granted us access to their databases. The Finnish Office of the Data Protection Ombudsman (Dnro 2794/402/2015) approved the data collection and combining of data registries.

Appendix 2 - Table 4: Characteristics for cases according to study year quartile

Variable	1997-2002 (n=1,839)	2003-2007 (n=1,921)	2008-2011 (n=2,020)	2012-2014 (n=1,841)	P-value
Age, median (IQR)	76 (70-82)	77 (71-82)	77 (70-83)	78 (70-84)	<0.001
60-69	439 (24%)	416 (22%)	466 (23%)	417 (23%)	<0.001
70-79	762 (41%)	781 (41%)	732 (37%)	621 (34%)	
80-89	560 (31%)	618 (32%)	713 (35%)	667 (36%)	
90+	78 (4%)	106 (5%)	109 (5%)	136 (7%)	
Sex					
Female	652 (36%)	659 (34%)	677 (34%)	623 (34%)	0.61
Male	1,187 (64%)	1,262 (66%)	1,353 (66%)	1,218 (66%)	
Hospital level					
University hospital	1,496 (81%)	1,689 (88%)	1,871 (93%)	1,751 (95%)	<0.001
Central hospital	343 (19%)	232 (12%)	149 (7%)	90 (5%)	
Re-operation^a	345 (19%)	405 (21%)	428 (21%)	348 (19%)	0.10
Dementia^b	179 (10%)	239 (12%)	242 (12%)	225 (12%)	0.036
1-year mortality	323 (18%)	305 (16%)	307 (15%)	305 (16%)	0.23

^aRe-evacuation of a chronic subdural hematoma within 1-year of the primary evacuation.

^bDementia diagnosis before or within 1-year of the chronic subdural hematoma evacuation.

Appendix 3 - Table 5: Multivariable logistic regression analysis for risk factors of 1-year case-fatality of cases

Variable	OR (95% CI)	P-value
Age (per year)	1.08 (1.06-1.08)	<0.001
Sex		
Male	1.00 (Reference category)	
Female	0.81 (0.71-0.92)	0.002
Year of primary operation		
1997-2002	1.00 (Reference category)	
2003-2007	0.84 (0.70-0.99)	0.047
2008-2011	0.78 (0.65-0.93)	0.005
2012-2014	0.82 (0.69-0.99)	0.036
Re-operation^a		
No	1.00 (Reference category)	
Yes	0.67 (0.56-0.79)	<0.001
Hospital level of care		
Central hospital	1.00 (Reference category)	
University hospital	0.93 (0.76-1.13)	0.45
Dementia^b		
No	1.00 (Reference category)	
Yes	1.50 (1.26-1.78)	<0.001
^a Re-evacuation of a chronic subdural hematoma within 1-year of the primary evacuation. ^b Dementia diagnosis before or within 1-year of the chronic subdural hematoma evacuation. Abbreviations: OR: Odds Ratio; CI: Confidence Interval.		

Appendix 4: Full list of references

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