Sudden death and suicide: a comparison of brain weight

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Background Recent evidence suggests that the brain weight of individuals over the age of 60 who commit suicide is significantly higher than in those who die of natural causes.

Aims To ascertain whether brain weight is different in people of a younger age who commit suicide than in those who die accidentally.

Method A retrospective review of post-mortem reports collecting height, weight and brain weight in 100 suicide victims (87 males, mean age 38.5 years) and 100 age/gender-matched controls who died accidentally or of natural causes (87 males, mean age 38.7 years). Comparison by *t*-test was made of brain weight in isolation as well as brain weight corrected for height, weight and body mass index.

Results These results reveal no significant difference in brain weight in suicide cases compared to the general population ($P > 0.05$). The brain weight of those who died by hanging was significantly higher than of those who died by overdose.

Conclusions Whatever the significant neuropsychiatric elements are that influence suicidal behaviour, they do not consistently affect brain weight in the population studied.

Declaration of interest None.

Salib & Tadros (2000) recently suggested that brain weight in people over 60 years of age who commit fatal self-harm is significantly higher than in those who die of natural causes. This was true for all suicide methods but there was no difference between suicide modes. Brain weight, structure and volume have been examined in several conditions. Courchesne *et al* (1999) reported that in 21 autopsy cases of autism, 17 brains were of normal weight, with 1 being microcephalic and another megalencephalic. Brown *et al* (1986) found that in schizophrenia, brain weight was reduced compared with age and gender-matched controls with affective disorders. Bruton *et al* (1990) showed that the brain weight of people with schizophrenia was lower than normal controls, even excluding other pathologies, whereas Hakim & Mathieson (1979) found similar results in Parkinson's disease. Mueller *et al* (1998), using quantitative volumetric magnetic resonance imaging, reported that the widespread loss of brain volume in the aged is most likely to be due to the onset of pre-clinical dementia, and that the healthy elderly had a low rate of brain volume reduction. Regarding suicide, Szigethy *et al* (1994) found that the left adrenal weight is increased in suicide victims and several groups. Roy (1992) and Yehuda *et al* (1988) have suggested that there is hypothalamic–pituitary–axis dysregulation in severe depression and suicidal patients. Schroder & Saternus (1983) found that brain weight was higher in victims of hanging in the general population.

Following the findings of Salib & Tadros (2000) we thought that it would be valuable to look at brain weight in suicide in a wider age range and also to compare suicide victims with those who died both accidentally and of natural causes. This would allow us to ascertain whether there was a difference in brain weight between those who have suicidal intent and those who do not. Methods of suicide could also be compared to see if these altered brain weight.

METHOD

Case selection

Suitable cases were selected using the post-mortem reports submitted to the HM Coroner for the City of Manchester during the period 1 January 1998 to 31 December 2000. Age, sex, height, weight, brain weight and cause of death were recorded. Body weight was measured unclothed and the brain was weighed, unfixed, on a self-calibrating digital balance (Model A & D FS-6K) at the time of removal from the cranium. The cases selected were then divided into suicidal deaths and age/gender-matched controls. For the purposes of this study, excess ethanol or methadone were considered to be accidental unless there was strong evidence in the clinical history to the contrary. Any cases in which all of these parameters were not present were discarded.

Comparison of data

Average brain weight in each group was then compared. Body mass index (BMI), defined as weight (in kg)/height^2 (m^2) was calculated and a comparison of the brain weight/BMI was made in the cases and controls. The ratios of brain weight/weight and brain weight/height were also compared. Standard deviation (s.d.) and 95% confidence intervals were calculated for each of these parameters. Mean differences were calculated and a paired *t*-test was used to ascertain whether the difference was significant. This was carried out for the entire case–control group but also separately for the two main modes of suicide, hanging and overdose. Analysis could not be performed on the other modes as the sample sizes were too small. Cases of death by accidental excess substance ingestion were also analysed separately. They were compared with both suicide cases and death by natural causes to assess whether there was any difference in brain weight depending on whether death was natural or unnatural, and whether unnatural death was intentional or accidental. Suicide cases were also compared to the natural-causes-only (excluding accidental overdose) group and the major subgroups of the suicide cases were compared to ascertain the effect of the method of death on brain weight.

Table 1 Causes of death for suicide victims

Cause of death	Number of cases
Carbon monoxide poisoning	2
Drowning	3
Hanging	53
Overdose	41
Struck by train	1

Table 2 Causes of death for control population

Cause of death	Number of cases	Cause of death	Number of cases
Cardiac[1]	17	Respiratory[2]	12
Gastrointestinal[3]	4	Hepatic[4]	10
Neoplasia[5]	4	Metabolic[6]	2
Neurological[7]	7	Septicaemia	2
Substance excess/misuse	35	Multiple injuries	4
Acute renal failure	1	Reaction to pseudoephedrine	1

1. Cardiac includes left ventricular failure (three), myocardial ischaemia (four), myocardial infarction (two), arrhythmia (three), cardiomyopathy (two), endocarditis (one), viral myocarditis (one) and bridging coronary arteries (one).
2. Respiratory includes pneumonia (six), aspiration pneumonia (one), pulmonary thromboembolus (one), aspiration of gastric contents (one), haemothorax (one) and asthma (two).
3. Gastrointestinal includes Mallory–Weiss tear (one), sigmoid volvulus (one), variceal bleed (one) and perforated diverticulum (one).
4. Hepatic includes alcoholic liver disease (two), steatosis (four) and hepatic failure (four).
5. Neoplasia includes carcinomatosis (one), acute myeloid leukaemia (one), testicular carcinoma (one) and mesothelioma (one).
6. Metabolic includes diabetic ketoacidosis (one) and hypoglycaemia (one).
7. Neurological includes epilepsy (five), vasovagal (one) and cerebral oedema (one).

RESULTS

Demographics

There were 100 cases and 100 age- and gender-matched controls that contained all of the data required. In each group, six of the patients were over 60 years old. Causes of death are given in Tables 1 and 2. Mean age for suicide victims was 38.5 years compared with 38.7 years for other cases. In both groups there were 87 males and 13 females.

Brain weights

Average brain weight in suicide cases was 1449 g (s.d. 161 g) compared with 1423 g (s.d. 161 g) in the control group. Average brain weight in males was 1468 g for suicide victims and 1449 g for the controls. In females, the average brain weights were 1251 g for suicides and 1322 g for the controls. BMI was calculated in the standard manner, giving values of 22.24 kg/m^2 for cases and 21.74 kg/m^2 for controls. Thus, when brain weight was compared to BMI, the result in suicide victims was 67.37 g/kg/m^2 (s.d. 14.1) and 68.1 g/kg/m^2 in the control group (s.d. 15.3). Mean brain weight/body weight was 21.2 (s.d. 4.12) in cases and 21.8 (s.d. 5.00) in controls. Mean brain weight/ height was 813 g/m in cases (s.d. 76.4) and 805 g/m (s.d. 85.1) in controls. The same calculations were performed for the male cases and controls only to exclude bias due to the lower average brain weight in females seen both in this study and in published data (Knight, 1996). These data are summarised in Table 3 and the data for brain weight controlled for BMI are shown in Figure 1.

Comparison of suicide victims and control group

Comparing brain weights gave a mean difference of 25.71 g (i.e. on average the

Table 3 Results for the suicide and control groups and their subgroups showing both the overall figures and those for male subjects only

Group	Mean age years (s.d.)	Mean BMI kg/m^2 (s.d.)	Mean brain weight g (s.d.)	Mean (brain wt/BMI) g/kg/m^2 (s.d.)	Mean (brain wt/body wt) g/kg (s.d.)	Mean (brain wt/ht) g/m (s.d.)
Suicide cases (n=100)	38.5 (13.8)	22.2 (4.1)	1449 (161)	67.4 (14.1)	21.2 (4.1)	813 (76.4)
Suicide cases (males only) (n=87)	38.4 (14.4)	21.7 (3.7)	1468 (162)	69.4 (13.3)	21.5 (4.0)	817 (79.0)
Hangings (n=53)	37.8 (16.2)	21.0 (3.1)	1480 (169)*	71.6 (11.5)*	22.2 (3.7)*	823 (79.2)
Hangings (males only) (n=50)	36.4 (16.1)	20.9 (3.0)	1499 (155)**	73.1 (10.8)**	22.4 (3.5)**	829 (77.9)
Deliberate overdose (n=41)	41.0 (10.7)	23.6 (4.7)	1386 (150)*	61.2 (14.7)*	20.2 (4.8)*	795 (81.3)
Deliberate overdose (males only) (n=30)	38.9 (10.6)	22.9 (4.6)	1421 (173)**	64.5 (15.9)**	20.3 (4.6)**	796 (81.4)
Controls (n=100)	38.7 (13.9)	21.7 (4.8)	1423 (161)	68.1 (15.3)	21.8 (5.0)	805 (85.1)
Controls (males only) (n=87)	38.8 (14.3)	21.8 (4.6)	1449 (152)	69.1 (17.1)	21.9 (5.3)	812 (85.2)
Accidental overdose (n=35)	33.1 (6.5)	21.4 (3.6)	1438 (139)	68.9 (12.4)	21.8 (4.7)	807 (88.7)
Accidental overdose (males only) (n=31)	32.5 (5.9)	21.4 (3.4)	1455 (127)	69.7 (12.1)	21.6 (4.3)	810 (91.5)
Natural (n=65)	41.7 (15.8)	22.0 (5.3)	1416 (67.8)	67.6 (16.8)	21.8 (5.2)	804 (83.7)
Natural (males only) (n=55)	42.6 (16.3)	21.9 (5.2)	1444 (127)	69.1 (17.1)	21.9 (5.3)	812 (85.2)

BMI, body mass index; wt, weight; ht, height.
*Difference between overall results for hanging and deliberate overdose groups. P=0.006 for brain weight in isolation, P<0.001 for brain weight/BMI and P=0.004 for brain weight/ body weight; **difference between hanging and deliberate overdose results for males only. P=0.047 for brain weight in isolation, P=0.013 for brain weight/BMI and P=0.034 for brain weight/body weight.
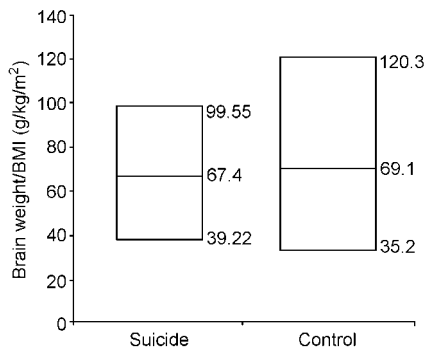
Fig. I Comparison of mean, minimum and maximum brain weights corrected for body mass index for suicide and control groups.

brain weight in suicide victims was 25.71 g heavier) with an s.d. of 193.4 g ($P=0.187$). Similarly, the differences between the brain weights controlled for BMI was 0.70 (s.d. 19.9, $P=0.727$). Brain weight corrected for weight gave a difference of 0.61 g/kg (s.d. 6.79, $P=0.368$). Brain weight corrected for height gave a mean difference of 8.45 g/m (s.d. 109, $P=0.441$). There were no significant differences between hangings and overdoses compared with natural deaths, or related to the chosen method and dying accidentally, or between suicidal and accidental overdose.

Comparison of those who committed suicide by hanging and overdose

However, when hanging victims were compared with those having deliberately overdosed, the difference in brain weight was 92 g (i.e. the brain in hanging was 92 g heavier than that in overdose). This was significant with a P value of 0.006. Controlled for BMI, the difference was 11.4 g/kg/m^2 ($P<0.001$) and the difference controlled for total body weight was 2.51 g/kg ($P=0.004$). The difference controlled for height was 29.0 g/m, but this was not significant. The comparison between hanging and deliberate overdose remained significant when this sample was confined to the males only. In this instance, difference in brain weight was 78 g ($P=0.047$). Controlled for BMI, the difference was 8.53 g/kg/m^2 ($P=0.013$) and for weight, 2.14 g/kg ($P=0.034$). The brain weight to height difference was 33.0 g/m, again not significant. The results for the subgroups (corrected for BMI) are shown in Table 3.

DISCUSSION

General observations

The data obtained in this study suggest that there is no difference in brain weight between suicide victims and their contemporaries who die suddenly of natural causes or accidentally. This remains true whether brain weight is examined in isolation or if it is corrected to take into account the body habitus. However, the brain weight in victims of hanging is significantly higher than in those who died by deliberate overdose. The absence of a significant difference between accidental substance excess and both the natural causes and suicide groups supports this assertion and also suggests that the ideation of suicide is not related to brain weight, either causally or as a secondary phenomenon. The average brain weight in both suicide and control groups falls within the average range as given by Knight (1996) for both males (1468 g and 1449 g respectively; normal range 1075–1685 g for the 30–39 age group) and females (1322 g and 1251 g, respectively; normal range 1038–1440 g for this age group).

These results show a slightly different picture to those of Salib & Tadros (2000). However, the parameters of the current study are also slightly different. We have used natural and accidental deaths as controls to ascertain whether those with suicidal intent have different brain weights to those who do not, and these data would suggest that there is no significant difference between these groups. There could be reasons why brain weight in the older population is higher in suicide victims, such as the presence of preclinical dementia in the control group, which would impair the ability to plan and carry out a suicide attempt. There is also a difference in the ages of patients in our group, with only 6% being over 60 years old.

Differences in brain weight between methods of suicide

Because the brain on average weighs 1.4% of the total body weight, we felt that brain weight looked at in isolation might give misleading results. We have attempted to avoid any bias by looking at brain weight in relation to height, weight and BMI. However, there was no significant difference between the study and control groups. We also compared the results for the different methods of suicide used. It must be

noted that the numbers for drowning (three people), carbon monoxide poisoning (two people) and train collision (one person) are very low and no attempt at statistical analysis has been attempted for these methods. More cases were available for the hanging and overdose groups and our results suggest that the brain weight in hanging is higher than that in overdose. If this difference in brain weight had been because of pre-mortem changes one would expect to see a significant difference for all modes of suicide. Therefore, we suggest that the observed difference results from congestion and oedema occurring during the act of hanging itself rather than a structural difference in the brain before a successful suicide attempt.

Possible confounding factors

Of course, there is the potential for several confounding factors. In the elderly population, degenerative brain diseases are more prevalent. In the younger group, it was difficult to collect a control population who died of completely natural causes, and even of those who do, the potential effect of disease on brain weight is unknown, although presumed to be slight. In the case of unnatural deaths (accidental overdoses and road traffic accidents), we do not know the effect of mode of death on brain weight. Many brains show a degree of hypoxic damage, which is probably an agonal event.

Future developments

Salib & Tadros (2000) recommended establishing a national database of findings following routine neuropathological examination of autopsy. In the current climate in autopsy pathology, this will require close cooperation between clinicians and pathologists to ensure that properly informed consent is obtained from relatives, notwithstanding the fact that the majority of autopsies in the context of suicide are performed within the coronial system. However, much useful information has been and can be gained from detailed structural and neurochemical studies of brains removed at autopsy from a range of psychiatric conditions, including those leading to suicide. Although the current study indicates that there are no differences in brain weight in a younger group of suicides (compared with the findings of Salib & Tadros, 2000), this should not

prevent further studies on brains from this group of individuals.

From our investigations, it would appear that whatever makes a person decide to take their own life does not appear to be related to the weight of the brain.

ACKNOWLEDGEMENTS

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CLINICAL IMPLICATIONS

■ Brain weight does not appear to be significantly higher in those with suicidal ideation than in those who die naturally or accidentally.

■ Higher brain weight in elderly suicide victims could be due to factors other than the fact that the victim is suicidal.

■ The method of suicide is a factor in brain weight at post-mortem.

LIMITATIONS

■ Retrospective study.

■ Post-mortems performed by several pathologists.

■ Can be difficult to assess suicidal intent after the fact. Coroners work on 'balance of probabilities', not 'beyond reasonable doubt'.

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