ORIGINAL ARTICLE

The Suicide Pandemic of Hydrogen Sulfide Poisoning in Japan

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Abstract

Background: Hydrogen sulfide (H_2S) suicides have been frequent in Japan in recent years. This study was performed to describe the epidemiologic profile of an outbreak of H_2S suicides in Japan.
Methods: In September 2008, questionnaires about patients involved in H_2S suicides were sent to 250 hospitals in Japan. Data collected from each patient included gender, age, clinical manifestations, date of event, location of suicide, source of H_2S, treatments and neurological outcome.
Results: A total of 90 subjects (60 men, 30 women) were enrolled in this study. In this outbreak, the first case was reported in September 2006 and subsequent cases reached a peak in April 2008. There were 60 cases of attempted suicide by generating H_2S gas (suicide group) and 30 cases of secondary exposure (secondary exposure group). The suicide group included mostly subjects in their twenties. Cardiopulmonary arrest at the scene was reported in 39 cases (65%). Clinical features of the suicide group inpatients included coma (14 cases), convulsion (1 case), and lung edema (1 case). Patients in suicide group were significantly younger than secondary exposure group ($P < 0.001$). The development of cardiopulmonary arrest was significantly higher in suicide group (65% vs. 10%; $P < 0.001$). Death was more frequent in suicide group (70% vs. 10%; $P < 0.001$) and patients with secondary exposure were discharged with better neurological outcomes (Table 1).
Conclusion: Suicide with H_2S poisoning has recently been a serious social problem especially in younger generation in Japan. There is extensive information on H_2S suicide methods on the internet. Management of access to websites describing suicide methods is an immediate necessity together with counseling for suicide prevention.

Keywords: Disease Outbreaks; Hydrogen Sulfide; Japan; Poisoning; Suicide

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INTRODUCTION

Hydrogen sulfide (H_2S) is a colorless, highly inflammable toxic gas, with a characteristic odor of rotten eggs (1-3). It is found in crude petroleum, natural gas, volcanic gas, and hot springs. It is also generated from industrial processes and natural deposits in sewers and manholes (1,4). Thus, H_2S poisoning can occur following accidental exposure.

The toxicity of H_2S poisoning is reversible by inhibiting cytochrome oxidase in the respiratory system (5). The clinical features of H_2S poisoning depend on the concentration of inhaled gas. At a concentration of over 30 parts per million (ppm), its odor can be detected and the olfactory nerve may become paralyzed at a level of over 150 ppm (3,4). Pulmonary and eye irritations occur at a level of over 200 ppm (4). Coma and cardiopulmonary arrest occur at a level of over 700 ppm due to brain respiratory center paralysis, asphyxia, and cardiac failure (4,6). A high H_2S concentration ($\geq$ 1000 ppm) immediately leads to unconsciousness and cardiopulmonary arrest; this is referred to as "knock down" (1).

H_2S suicides are frequent in Japan (1,7-9). Furthermore, individuals who try to help the victims or those who are present at the scene may be exposed to the gas and suffer from secondary poisoning. The objective of this study was to describe the epidemiologic profile of an outbreak of H_2S suicides in Japan.

METHODS

In September 2008, questionnaires about patients involved with H_2S poisoning were sent to 250 hospitals, including emergency medical centers and university hospitals, in Japan. Data collected from each patient included gender, age, clinical manifestations, date of event, location of suicide, source of H_2S, treatments and neurological outcome. The Cerebral Performance Category (CPC) was used to assess neurological outcome at hospital discharge (10):

CPC1. Conscious, alert, possible mild neurological or psychological deficit, able to work; CPC2. Conscious, moderate neurological disability, conscious, sufficient cerebral function for independent activities of daily life, able to work in sheltered environment; CPC3. Conscious, severe

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neurological disability, dependent on others for daily support because of impaired brain function; CPC4. Coma or vegetative state; and CPC 5. Brain death: apnea, areflexia, EEG silence.

The data are shown in terms of frequency and percentage using Microsoft Office Excel® 2010 (Microsoft Corp., Redmond, WA, USA). The data on age are shown as mean (SD). Statistical analysis was performed with Statview 5.0® (SAS Institute Inc., Cary, NC, USA). Student's t test was used to compare age between two groups and compare continuous variables and the chi-square was used to analyze categorical variables.

RESULTS

A total of 90 subjects (60 men, 30 women) from 34 (response rate: 13.6%) hospitals responded (Table 1). There were 60 cases (42 men, 18 women) of attempted suicide by inhalation of H_2S gas (suicide group) and the 30 cases (18 men, 12 women) of gas exposure after attempting to rescue the victims or from being present in the scene (secondary exposure group). The first cases of H_2S poisoning were reported in September 2006 and reached a peak in April 2008 (Figure 1).

Suicide group

In the suicide group, the mean age was 28.8 (9.1) years (range: 17–51 years) (Figure 2). The cases of attempted suicide were more frequent among men and women in their twenties (34 cases; 57%). Cardiopulmonary arrest at the scene was reported in 39 cases (65%); while in two of those cases, there was return of spontaneous circulation; however, they died 4 and 22 days after the suicide attempt, respectively. Patients who suffered from cardiac arrest at the scene due to high concentration of H_2S did not survive despite cardiopulmonary resuscitation and antidote administration. However, the patients who escaped early from H_2S gas were successfully treated.

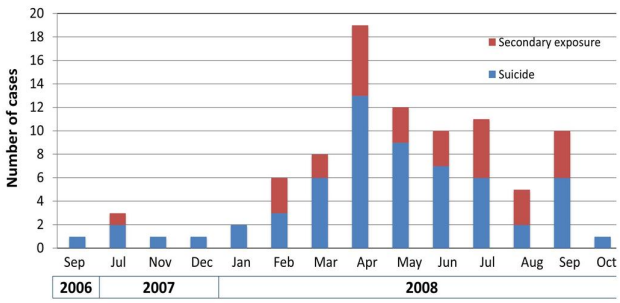

Figure 1. Frequency of suicides with hydrogen sulfide poisoning during the study period

Twenty-three subjects (38%), in total were admitted to hospitals. Their clinical manifestations included coma in 14 cases, convulsion in 1 case, and lung edema in 1 case (Table 1). In 51 cases, H_2S was generated by mixing hydrochloric acid detergent with any of the following: sulfur-based bath additive (MUTOHAP®) in 40 cases (78%), sulfur-based pesticide in 8 cases (16%), sulfur-based bath powder in 2 cases (4%), or a combination of sulfur-based bath additive (MUTOHAP®) and sulfur-based pesticide in 1 case (2%) (Table 2). The place where the gas was generated was reported in 58 cases including bathroom in 25 cases (43%), car in 12 cases (20%), bedroom in 10 cases (17%), and toilet in 7 cases (12%) (Figure 3). Among those admitted to the hospital (suicide inpatient group: 23 cases), 9 patients were intubated (39%); antidote therapy was given using inhaled amyl nitrite, followed by intravenous sodium nitrate in 3 cases (13%) or sodium nitrate in 5 cases (22%); and hyperbaric oxygen therapy was used in 2 cases (9%) (Table 1).

Table 1. Demographic characteristics, clinical features, and outcomes of the patients with hydrogen sulfide poisoning.

	Total (n = 90)	Suicide (n = 60)	Secondary exposure (n = 30)	P value
Demographic				
Male/Female; n	60/30	42/18	18/12	0.34
Age; mean (SD)		28.8 (9.1)	44.1 (19.7)	< 0.001
Admission to hospital; n (%)	50 (56)	23 (38)	27 (90)	< 0.001
Clinical findings				
Cardiopulmonary arrest; n (%)	42 (47)	39 (65)	3 (10)	< 0.001
Coma; n (%)	17 (19)	14 (23)	3 (10)	0.12
Lung edema; n (%)	3 (3)	1 (2)	2 (7)	0.21
Convulsions; n (%)	2 (2)	1 (2)	1 (3)	0.61
Outcomes				
Death in total; n (%)	45 (50)	42 (70)	3 (10)	< 0.001
Death in hospital; n (%)	5 (6)	5 (22)	0 (0)	0.10
CPC 1; n (%)	44 (49)	17 (28)	27 (90)	0.001
CPC 2; n (%)	1 (1)	1 (2)	0 (0)	0.61

Table 2. Treatments administered to hydrogen sulfide poisoned inpatients (n = 50)

Treatment	Total (n = 50)	Suicide (n = 23)	Secondary exposure (n = 27)	P value
Intubation; n (%)	11 (22)	9 (39)	2 (7)	0.003
Amyl nitrite + Sodium nitrite; n (%)	3 (6)	3 (13)	0 (0)	0.05
Sodium nitrite; n (%)	7 (14)	5 (22)	2 (7)	0.14
Hydroxocobalamine; n (%)	0 (0)	0 (0)	0 (0)	---
Hyperbaric oxygen; n (%)	2 (4)	2 (9)	0 (0)	0.05

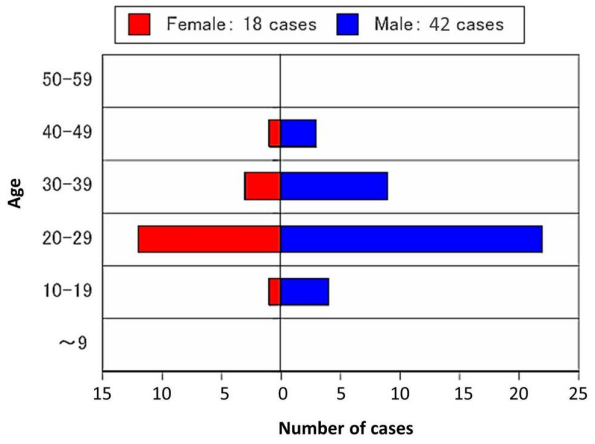

Figure 2. Demographic features of the hydrogen sulfide suicide group

In the suicide inpatient group, 5 patients died, 17 patients had a CPC score of 1 and one patient had a CPC score of 2, at discharge.

Secondary exposure group

In the secondary exposure group, the mean age was 44.1 (19.7) years (range: 1–84 years) (Table 1). The place where the gas was exposed was reported in 26 cases: bathroom in 8 cases (31%), bedroom in 8 cases (31%), neighborhood in 5 cases (19%), toilet in 3 cases (12%), and car in 2 cases (8%).

Three subjects developed cardiac arrest at the scene and died. Twenty-seven subjects were admitted to the hospital (secondary exposure inpatient group), and their clinical manifestations included coma in 3 cases, convulsion in one case, and lung edema in 2 cases. In the secondary exposure inpatient group, 2 patients (7%) were intubated and antidote therapy was given using intravenous sodium nitrate in 2 cases (7%) (Table 2). All of the patients in the secondary exposure inpatient group were discharged from the hospital without neurological sequelae (CPC1).

Analysis of factors and outcomes

Comparing suicide group and secondary exposure group (Table 1), it was found that patients in suicide group were significantly younger (28.8 vs. 44.1 yrs.; $P < 0.001$). Nevertheless, patients in secondary exposure group were more likely to survive and be admitted to hospital (38% vs. 90%; $P < 0.001$). The development of cardiopulmonary arrest was significantly higher in suicide group (65% vs. 10%; $P < 0.001$), while there was no significant difference in other clinical findings between the two groups. Yet, patients with secondary exposure to H2S needed to specific and aggressive treatments in a much smaller extent (Table 2). In addition, death was more frequent in suicide group (70% vs. 10%; $P < 0.001$) and patients with secondary exposure were discharged with better neurological outcomes (Table 1).

DISCUSSION

Japan has a high suicide rate, and the number of annual suicides is estimated to be over 30,000 (11,12). Although the suicide rate among men is increasing, this number has remained unchanged among women (13). The gender ratio (male/female) in Japan was 2.7 in 2009 and 2.23 among patients aged 20 to 29 years (14). Two peaks in suicide rate were seen among men, i.e., middle aged (50–59 years) and the elder (> 80 years), whereas the suicide rate of women gradually increases with aging (15). Poisoning after suffocation/hanging is the most frequently reported method of suicide among people aged 20 to 29 years in Japan (13,14).

We performed a hospital-based analysis of the outbreak of H_2S suicides in Japan. The new suicide method of generating H_2S, i.e., mixing hydrochloric acid detergent with a sulfur-based bath additive (MUTOHAP®), was reported in 2007 (7). Our study revealed that the new method had already been used in 2006. A total of 1056 subjects were reported dead due to H_2S poisoning in 2008, compared to only 19 cases in 2007 (7,8). In the present study, H_2S suicides were reported mainly in young subjects (20-29 years). Therefore, the population of subjects committing H_2S suicide is different from that of all suicide deaths in Japan (7).

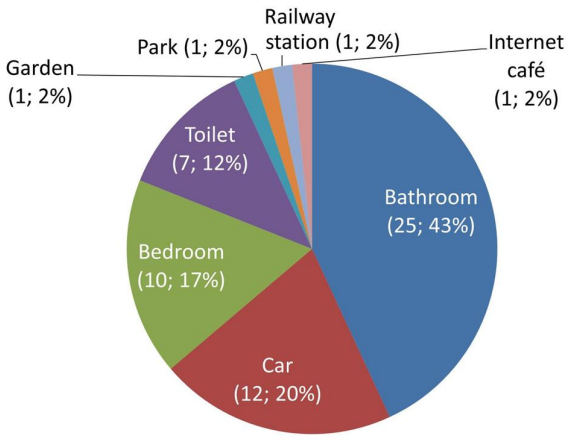

Figure 3. Location of hydrogen sulfide gas generation in suicide group

The outbreak of H_2S suicide was found to be associated with available information of producing this substance on the internet (1,8). A website describing how to use H_2S for suicide was available and it listed the methods to generate H_2S gas, including the adequate amount of hydrochloric acid detergent and sulfur-based bath additive (MUTOHAP®) and provided information on how to make this gas available to others (1). Furthermore, the website recommended using a confined place to generate a high concentration H_2S gas, for example, in a car or a toilet. At the same time, newspapers, television and other mass-media reported daily H_2S suicides, reaching a peak around April 2008 (8,9). Considering the increase in H_2S suicide attempts, newspapers and television offered access limitation to the substance and the website was restricted to access. Moreover, unrelated to the abovementioned events, MUTOHAP® was discontinued in April 2008. Accordingly, the number of the H_2S suicide attempts decreased gradually, although they are still reported. In the same manner, the same setup was observed in the United States with the dissemination of information about suicide methods via the internet (16).

The H_2S poisoning mostly manifests with neurological and/or pulmonary signs and symptoms. Central nervous system effects include dizziness, headache, convulsions, coma, and respiratory center paralysis (2,17,18). Pulmonary effects include wheezing, dyspnea, bronchiolitis, pulmonary edema, and acute respiratory distress syndrome (ARDS) (2,17,18). Myocardial symptoms such as arrhythmia and dilated cardiomyopathy have also been reported in some cases (2,18,19). Furthermore, Arnold et al. reported that unconsciousness, headache, nausea/vomiting, dyspnea, disequilibrium, lung edema and convulsion can be found in subjects with occupational exposure to H_2S (18).

In this study, 42 patients (46%) in total developed cardiopulmonary arrest at the scene. Correspondingly, Inoue et al. and Amino et al. reported 2 cases of sudden death due to myocardial injury and 1 case of heart failure among subjects who attempted H_2S suicide (20,21). Myocardial effects related to H_2S poisoning are noticeable when high concentrations of the gas are inhaled (2). Accordingly, patients with secondary exposure in the present study that were less exposed to the gas and not in direct contact in the very first minutes, experienced this complication in a much lesser extent.

The initial management of patients with H_2S poisoning includes immediate removal from the area of gas exposure, supplemental oxygen, and eye and skin decontamination (5). Intubation and ventilation should be performed, depending on the patient's condition. Additionally, administration of nitrites has been widely used in the treatment of H_2S poisoning (2). This treatment should be initiated with inhalation of amyl nitrite until sodium nitrite can be injected intravenously (22). Recently, hydroxocobalamin was reported to be effective on reducing serum concentration of sulfide and thiosulfate, in patients with H_2S poisoning (3). Hyperbaric oxygen therapy has also been shown effective in some cases of H_2S poisoning (23-25). In this study, intravenous sodium nitrite combined with inhaled amyl nitrite was administered to 3 cases. However, no patient was treated with intravenous hydroxocobalamin. Moreover, it was found that patients with suicidal attempt had poorer prognosis and needed to more aggressive treatments compared to patients with secondary exposure.

LIMITATIONS

In this study, data were not directly collected by the researchers and were collected retrospectively with questionnaires, which may cause bias in data collection. Although some emergency departments in Japan cooperated with this study, all patients with H_2S poisoning could not be covered and hence the actual condition may not be properly reflected.

CONCLUSION

Suicide with H_2S poisoning has recently been a serious social problem especially in younger generation in Japan. There is extensive information on H_2S suicide methods on the internet. Management of access to websites describing suicide methods is an immediate necessity together with counseling for suicide prevention.

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