TURKISH JOURNAL OF EMERGENCY MEDICINE

Original Article

Access this article online

Quick Response Code:

Website: https://turkjemergmed.com/

DOI: 10.4103/tjem.tjem_213_23

Outcome of early emergency intubation and early emergency dialysis in deliberate self-harm with formic acid in a tertiary care center in South India: A retrospective cohort study

Rahul Balasubramanian[1], Jobin Jose Maprani[2], Sandra Paulson[3], Suresh G[4], S Manu Ayyan[5], Vimal Rohan K[6]

[1]Department of Emergency Medicine, St James Hospital, Chalakudy, Thrissur, Kerala, India, [2]Department of Emergency Medicine, Amala Institute of Medical Sciences, Thrissur, Kerala, India, [3]Department of Community Medicine, Amala Institute of Medical Sciences, Thrissur, Kerala, India, [4]Department of Emergency Medicine, Government Medical College, Kannur, Pariyaram, Kerala, India, [5]Department of Emergency Medicine & Trauma, Jawaharlal Institute of Postgraduate Medical Education & Research, Puducherry, India, [6]Department of Emergency Medicine, Government Medical College Kannur, Pariyaram, Kerala, India

**Corresponding author*

Abstract:

OBJECTIVE: The objective is to evaluate the outcome of early emergency intubation and early dialysis in formic acid (FA) poisoning and to determine the clinical features associated with its mortality.

METHODS: It is a retrospective cohort study of 78 patients who presented to the emergency medicine department from July 2008 to June 2015 with alleged history and clinical features of FA poisoning. The outcome of early intubation and early dialysis was studied in terms of 7-day and 30-day mortality. The outcome was compared in severe and not severe groups separately. Severity was graded according to Med-Tu chart used for corrosive poisoning.

RESULTS: In the severe group ($n = 53$), early dialysis was done in 15 patients. There was 53% ($n = 8$) 30-day mortality. In the group where early dialysis was not done there was a significant increase in mortality 92.1% ($n = 35$). This was statistically significant with a $P = 0.003$. In a similar fashion 7-day mortality was analyzed in the severe group where mortality was higher when early dialysis was not done. In not severe group early dialysis has minimally decreased the mortality. Early intubation in severe group did not demonstrate any mortality benefit. Patients who were intubated early and not intubated early had equally high mortality. In not severe group, intubation could not make any significant difference in mortality.

CONCLUSION: In this retrospective study, we observed that early dialysis in the severe group has a better outcome in terms of 7-day and 30-day mortality.

Keywords:

Corrosive, dialysis, emergency medicine, formic acid, intubation, mortality

Submitted: 03-10-2023
Revised: 20-01-2024
Accepted: 21-01-2024
Published: 04-04-2024

ORCID:
RB: 0009-0000-0589-8954
JJM: 0009-0005-3772-2554
SP: 0000-0002-3040-6883
GS: 0009-0005-1029-9901
SMA: 0000-0002-2541-5769
KVR: 0009-0009-7808-6426

Address for correspondence:
Dr. Jobin Jose Maprani, Department of Emergency Medicine, Amala Institute of Medical Sciences, Amalanagar, Thrissur - 680 005, Kerala, India.
E-mail: jobinjosem@gmail.com

How to cite this article: Balasubramanian R, Maprani JJ, Paulson S, Suresh G, Ayyan SM, Vimal Rohan K. Outcome of early emergency intubation and early emergency dialysis in deliberate self-harm with formic acid in a tertiary care center in South India: A retrospective cohort study. Turk J Emerg Med 2024;24:111-6.

Box-ED section

What is already known about the study topic?

- Formic acid (FA) is a toxic and corrosive chemical agent used for industrial purpose
- FA ingestion is a relatively common method of deliberate self-harm as it is easily accessible at homes in Northern Kerala, South India
- Mortality is very high in FA poisoning and existing literature on the topic is limited.

What is the conflict on the issue? Has it importance for readers?

- The role of immediate early intubation and early dialysis in the treatment of patients who have been successfully resuscitated after FA poisoning remains uncertain
- The right timing and intervention may increase survival or improve discharges in majority of patients.

How is this study structured?

- This was a single-center, retrospective cohort study includes data from approximately 78 patients.

What does this study tell us?

- There was significant decrease in 7-day mortality and 30-day mortality in severe as well as not severe groups who underwent early dialysis. However, patients who underwent early intubation did not benefit from any significant difference in mortality in our study sample.

Introduction

Formic acid (FA) is a toxic chemical compound that has application in both agriculture and industry. Rubber latex is coagulated using a diluted solution of FA. In rubber-growing regions, rubber processing is done as a cottage business, which leaves FA readily available in homes. Its simple accessibility in homes makes it a popular agent for intentional self-harm in the northern part of Kerala. Other sectors that employ FA include paper, tanning, electroplating, and disinfectant manufacturing.[1]

FA poisoning has a significant death rate. Because FA is corrosive, irritating, and fuming, FA toxicity affects the respiratory system.[2] When they arrive at the emergency department (ED) on time, their airway is protected by early endotracheal intubation while under laryngoscopic visualization. This guarantees sufficient oxygenation of the tissue, which improves the prognosis. FA can be dialyzed because of its comparatively low molecular weight. Since hemodialysis reverses the systemic effects of FA, it proves to be an effective treatment.[3,4] Renal failure and severe metabolic acidosis are caused by FA. FA is a protoplasmic toxin that damages cells by acting directly on proteins or indirectly on tissue ions.[5]

Although FA poisoning and intentional self-harm are relatively common in our state, there are few research on the subject in the literature. Evaluating the effects of these two interventions, which are implemented one after the other in their respective departments, is extremely insightful. In light of this, a study was carried out to determine how early intubation and dialysis enhance survival in cases of intentional self-harm involving the intake of FA.

Methods

The study is carried out at a teaching institution at the tertiary level that handles an extensive number of emergencies in the state's northern region. This retrospective cohort study was carried out on patients who were diagnosed with intentional self harm using FA and who were older than 18 years. After receiving approval from the institute's ethical and research committees, patients who were diagnosed with intentional self harm using FA and admitted to the hospital between July 2008 and August 2015 were included as study participants. After getting clearance from the Ethics Committee and Research Committee of the institute, demographic data, symptoms at presentation to the ED, investigations, and acute complications (hematuria, respiratory distress, oropharyngeal burns, hematemesis, melena, drooling of saliva, vomiting, gastrointestinal [GI] perforation, and dyspnea) were recorded from the case records as well as telephonic interviews. Patient consent was not taken due to the retrospective nature of the study; secondary data from the patient's case sheet were collected on a case-to-case basis. The study was certified by the Institutional Ethical and Research Committee of Academy of Medical Sciences Pariyaram, Kannur, Kerala, India, as per reference no. 23/2014/ACME dated February 07, 2014.

All the patients were managed by securing airway patency and supportive care that included intravenous fluids, correction of acidosis, and prophylactic antibiotics, along with blood transfusions and hemodialysis when indicated.

Depending on the severity of their toxic exposure, patients were split into two groups: Severe and not severe. The Med-Tu chart, which is used to grade corrosive toxicity, was followed for determining the severity of the condition.[6] In each group, the results of early dialysis and early intubation were examined independently. Any intubation performed within 4 h of FA use is considered early intubation. Dialysis completed 5 h or less after ingesting FA was regarded as early.[6]

Criteria for inclusion

Any patient over the age of eighteen who came to the ED claiming to have a history of intentional self-harm

using FA exclusion criteria: Patients whose record data could not be obtained.

For descriptive statistics, the continuous variables are presented as median with interquartile range (IQR) and categorical variables as absolute numbers and percentages. All data were assessed for the normality assumption by a Shapiro–Wilk test. Differences between the groups based on mortality were compared with independent-samples *t*-test for the continuous variables and Chi-square test (with yates continuity correction) for the categorical data. The association of symptoms and signs on admission (hematuria, respiratory distress, oropharyngeal burns, hematemesis, melena, drooling of saliva, vomiting, GI perforation, dyspnea), concentration of FA used for consumption, as well as complications of FA poisoning and mortality (30-day mortality), were analyzed using Chi-squared tests. The study was certified by the Institutional Ethical and Research Committee of Academy of Medical Sciences, Pariyaram, Kannur, as per reference no. 23/2014/ACME dated February 07, 2014.

Results

During the study, a total of 90 patients had presented to the ED with deliberate self-harm with FA out of which only 78 were included in the study since the records of the 12 study participants were not available. Figure 1 shows the flow diagram of the study participants. Patients were graded to severe and not severe in accordance with Med-Tu chart. 53 (68%) were severe and 25 (32%) were not severe. Table 1 shows the demographic, clinical, and biochemical profile of the study participants.

Figure 2 depicts the different interventions that the patients underwent. The different combinations and their frequency are clearly mentioned. Patients were graded to severe and not severe in accordance with Med-Tu chart. 53 (68%) were severe and 25 (32%) were not severe. The primary outcomes were 7-day and 30-day mortality. Out of 25 cases, 21 (84%) had no mortality in 30 days. In the severe group, 43 (81.1%) had mortality in 30 days. Only 10 (18.9%) patients survived after 30 days in severe group. In 78 patients, 47 (60.2%) had 30-day mortality. Total mortality on day one and 30 days were 47% and 60%, respectively.

At the conclusion of 30 days, Table 2 compares the clinical, biochemical, and demographic features of deceased individuals and those who survived.

Table 1: Demographic, clinical, and biochemical profile of study participants

Characteristics of study participants	Frequency (percentage)
Demographic pattern of study participants	
Age (years), median (IQR)	51.86 (15.15)
Female, *n* (%)	31 (40)
Male, *n* (%)	47 (60)
Time lag in presentation (IQR) (h)	2 (1.5)
Quantity of acid ingested (mL)	120 (30)
Biochemical parameters, median (IQR)	
PT INR	1.7 (2)
pH, mean±SD	7.14±0.18
Lactate (mmol/dL)	4.178 (2.36)
WBC count	17.86 (7.93)
MAP (mmHg)	95.2 (25.6)
Presenting clinical symptoms - total, *n* (%)	
Vomiting	41 (52.6)
Hematuria	58 (74.4)
Oropharyngeal burns	49 (62.8)
Hematemesis	18 (23.1)
Drooling of saliva	40 (51.3)
Abdominal pain	26 (33)
Dyspnea	12 (15.4)
Dysphagia	4 (5.1)
Malena	4 (5.1)
Hemoptysis	6 (7.7)

MAP: Mean arterial pressure, IQR: Interquartile range, WBC: White blood cell, SD: Standard deviation, PT: Prothrombin time, INR: International normalized ratio

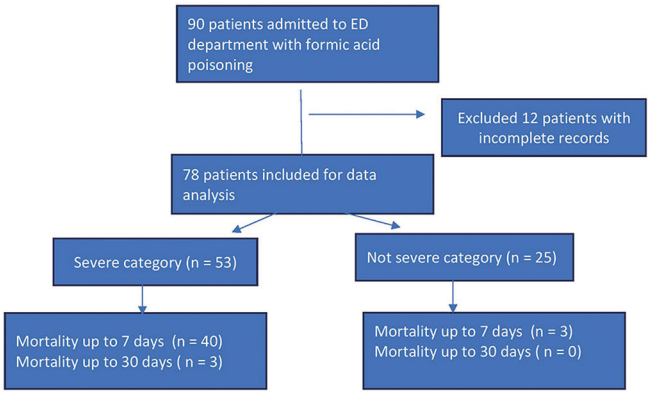

Figure 1: Flow diagram of study participants. ED: Emergency department

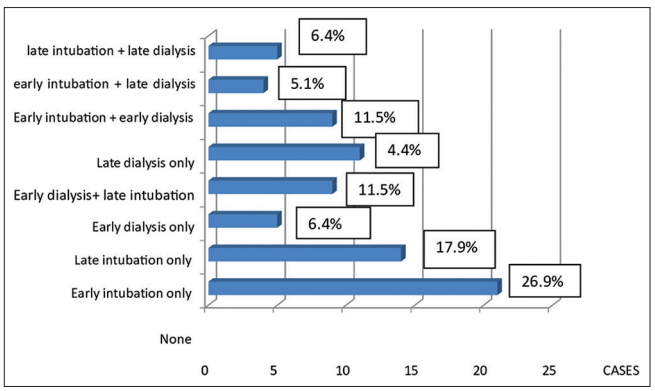

Figure 2: Distribution-of-interventions-done

Table 2: Association of demographic, clinical and biochemical parameters with 30-day Mortality

	30 day mortality (*n*=47)	No 30-day mortality (*n*=31)	*P*#
Age	55.89±14.92	45.74±13.55	0.003*
MAP (mmHg)	10±3	15±3	0.693
pH	7.10±0.24	7.31±0.15	<0.001*
Time lag in presentation (h)	4±3.94	4.5±3.38	0.386
Lactate	5±2	2±2.9	<0.001*
GCS	10±3	15±3	<0.001*
Quantity (mL)	120±30	120±30	0.233
WBC count	18.5±11	15±12.9	0.006*
PT INR	2±2.1	1±3	<0.001*
Hospital stay (days)	1±0	7±9	<0.001*
Clinical features	**30 day mortality, *n* (%)**		
Free fluid in abdomen (*n*=11)	11 (100)		
Visual symptoms (*n*=1)	1 (100)		
GI perforation (*n*=16)	15 (93.8)		
Dyspnoea on presentation (*n*=15)	13 (83.3)		
Oropharyngeal burns (*n*=49)	40 (81.6)		
Abdominal pain (*n*=26)	21 (80)		
Hematuria (*n*=58)	43 (74)		
Drooling of saliva (*n*=40)	27 (67)		
Malena (*n*=4)	2 (50)		
Vomiting (*n*=41)	20 (48.8)		
Hematemesis (*n*=19)	5 (24.4)		

*Statistically significant, #Independent *t*-test used. MAP: Mean arterial pressure, WBC: White blood cell, PT: Prothrombin time, INR: International normalized ratio, GCS: Glasgow coma scale

Table 3: Mortality at day 7 and day 30 based on early dialysis

	Outcome at 7 days			Outcome at 30 days		
	Died	Alive	*P*	Died	Alive	*P*#
Severe category (*n*=53), *n* (%)						
ED done	8 (15.1)	7 (13.2)	0.032*	8 (15.1)	7 (13.2)	0.003*
ED not done	32 (60.4)	6 (11.3)		35 (66)	3 (5.7)	
Not severe category (*n*=25), *n* (%)						
ED done	0	3 (12)	0.495	0	3 (12)	0.420
ED not done	3 (12)	19 (35.8)		4 (16)	18 (72)	

*Statistically significant, #Chi-square test used. ED: Early dialysis

Table 4: Mortality at day 7 and day 30 based on early intubation

	Outcome at 7 days			Outcome at 30 days		
	Died	Alive	*P*#	Died	Alive	*P*#
Severe category (*n*=53), *n* (%)						
EI done	19 (35.8)	6 (11.3)	0.93	20 (37.7)	5 (9.4)	1.00
EI not done	21 (39.6)	7 (13.2)		23 (43.3)	5 (9.4)	
Not severe category (*n*=25), *n* (%)						
EI done	0	2 (8)	0.586	0	2 (8)	0.520
EI not done	3 (12)	20 (80)		4 (16)	19 (76)	

#Chi-square test used, No statistical significance. EI: Early intubation

Differences between the groups based on mortality were compared with an independent-sample *t*-test for the continuous variables and Chi-square test (with yates continuity correction) for the categorical data. The $P < 0.05$ was taken to be statistically significant. The difference in the mortality pattern of patients who underwent early dialysis and early intubation can be seen in the data presented in Tables 3 and 4.

Discussion

There was a noteworthy rise in mortality of 92.1% ($n = 35$) in the group that did not receive early dialysis. At $P = 0.003$, this was statistically significant. The severe group's 7-day mortality was examined in a similar manner. The death rate for patients who started dialysis early was 53% ($n = 8$). When early hemodialysis was not performed, mortality

rose to 84.2% ($n = 32$) ($P = 0.032$). Three patients (12%) in the not-severe group ($n = 25$) underwent early dialysis, and after 30 days, there was no fatality. Twenty-two patients did not receive early dialysis. 18.2% of the population died ($P = 0.420$). When 7-day mortality was calculated, there was no mortality in the group receiving early dialysis, and in the group who did not, there was a mortality rate of 13% ($n = 3$) ($P = 0.586$). The results that we got in the study are in consensus with the data in the literature.[7,8]

Severe intravascular hemolysis is indicated by the rapid appearance of hemoglobinuria. Studies carried out on animal models *in vivo* and *in vitro* are less frequent because hemodialysis expedites the removal of FA and helps rectify metabolic acidosis. Hemodialysis lowers the amounts of FA in blood and other bodily fluids, as demonstrated by endogenous and hemodialysis elimination of FA (Fick principle).[9] In the absence of dialysis, the elimination half-life of FA is 6.04 ± 3.26 h ($P = 0.004$). This exceeds the elimination half-life (1.80 ± 0.78 h) determined during dialysis. This evidence clearly shows that systemic toxicity is reduced when FA is consumed early in the dialysis process.[10] In addition, early dialysis helps lessen the strain on the liver, where it gets metabolized as demonstrated in rat liver models.[11]

A case report presents yet another piece of data supporting the importance of early hemodialysis.[12] In one instance, the concentration of the blood drawn upon hospital admission was 370.3 μg/mL; however, after 6.5 h of hemodialysis, it dropped to 13.9 μg/mL. It demonstrates how early hemodialysis lowers blood FA's absolute concentration.[13-20] In 47.1% of instances ($n = 25$) in the severe category, early intubation was performed. Within 30 days, there was an 80% ($n = 20$) mortality rate in this group.

In 28 patients, early intubation was not done. The mortality rate in this group was 82.1% ($P = 1.00$). Similarly, after 7 days, the mortality rate for the group receiving early intubation ($n = 25$) was 76% ($n = 19$), while the mortality rate for the group receiving delayed intubation ($n = 28$) was 75% ($P = 0.93$). Only two patients (8%) in the not severe group ($n = 25$) underwent early intubation; both patients lived for a full 30 days. Of the patients, 23 (92%) did not have an early intubation, and the mortality rate was 17.4% ($n = 4$) ($P = 0.520$). In a similar vein, just two patients underwent early intubation in a span of 7 days, and both of them recovered. An IQR of 30 indicates the importance of early hemodialysis, grouping where early intubation was not done, mortality was 13% ($n = 3$) ($P = 0.586$). When poisoning is severe, the outcome may be more dependent on systemic effects and other local effects of FA, such as GI perforation, than the outcome due to intubation.

The greatest predictors for mortality in our study were dyspnoea on presentation, GI perforation, free fluid in the abdomen, and visual symptoms, with percentages of 100%, 100%, 93.8%, and 83.3%, respectively. 33.4% (101) of mucosal erosions and 32.1% (97) of oral ulcerations in Dalus *et al*.'s study had severe mouth burns. They came to the conclusion that one of the best indicators of death is oropharyngeal burns.

Oropharyngeal burns are one of the factors we used in our study to grade burn severity. In addition, a high correlation between oropharyngeal burns and death is demonstrated by our study. Of the 49 (62.8%) patients with oropharyngeal burns, 40 (81.6%) died within 30 days. Twenty-two (37.2%) of the patients who did not have oral burns died within 30 days ($P = 0.00$). Saliva drooling was observed in 40 (51.3%) of the patients. Twenty-seven (67%) of the individuals in the group died within 30 days. Yet another clinical characteristic for grading severity is the drooling of saliva. In our analysis, 16 patients (20.5%) experienced perforation; of these, 15 (94%) died within 30 days ($P = 0.002$). According to a study by Dalus *et al*, 39 people (12%), had GI perforations. In this, there was a 100% death rate. Thus, the findings in both studies are comparable.[7,21]

Limitations

1. This is a single-centred retrospective study, so can be subjected to selection bias. Which may affect the external validity of the findings
2. The time for early intubation was arbitrarily chosen
3. Loss of records results in selection bias and an overestimate or an underestimate of an association.

Conclusion

The study was conducted with the aim of assessing the outcome of early emergency intubation and early emergency dialysis in patients with deliberate self-harm with FA. We observed that early emergency dialysis of patients in the severe group significantly decreased 7-day ($P = 0.033$) mortality and 30-day ($P = 0.003$) mortality. In the not severe group, mortality was lower compared to the severe group but early dialysis has not significantly reduced the 7-day and 30-day mortality rates when compared to the severe group. Emergency clinicians should focus on the early emergency dialysis of patients presenting with FA ingestion. In the not severe group, the presence of clinical features associated with mortality has to be considered too.

Author contributions statement

RB: Conceptualization (lead); writing – original draft (lead); formal analysis (lead); writing – review and editing (equal). JM: Methodology (lead); writing – review and editing (equal). SP: Conceptualization (supporting); Writing – original

draft (supporting); Writing – review and editing (equal). SG: Conceptualization (supporting); Project Administration (lead). MA: Software (lead); writing – review and editing (equal). VRK: Supervision (lead); Resources and Software (supporting).

Conflicts of interest
None Declared.

Ethical approval
The study was certified by the Institutional Ethical and Research Committee of Academy of Medical Sciences Pariyaram, Kannur, Kerala, India, as per reference no. 23/2014/ACME dated February 07, 2014.

Consent to participate
Not taken due to the retrospective nature of the study, secondary data from the patient's case sheet were collected on a case-to-case basis from the Academy of Medical Sciences, Pariyaram.

Funding
None.

References

1. Havanond C, Havanond P. Initial signs and symptoms as prognostic indicators of severe gastrointestinal tract injury due to corrosive ingestion. J Emerg Med 2007;33:349-53.
2. Toxnet Data – Pubchem (no date) National Center for Biotechnology Information. PubChem Compound Database. Available from: https://pubchem.ncbi.nlm.nih.gov/docs/toxnet. [Last accessed on 2023 Oct 16].
3. Naik RB, Stephens WP, Wilson DJ, Walker A, Lee HA. Ingestion of formic acid-containing agents – Report of three fatal cases. Postgrad Med J 1980;56:451-6.
4. Westphal F, Rochholz G, Ritz-Timme S, Bilzer N, Schütz HW, Kaatsch HJ. Fatal intoxication with a decalcifying agent containing formic acid. Int J Legal Med 2001;114:181-5.
5. Yang CC, Ger J, Li CF. Formic acid: A rare but deadly source of carbon monoxide poisoning. Clin Toxicol 2008;46:4, 287-9. [doi: 10.1080/15563650701378746].
6. Chan TC, Williams SR, Clark RF. Formic acid skin burns resulting in systemic toxicity. Ann Emerg Med 1995;26:383-6.
7. Dalus D, Mathew AJ, Somarajan Pillai S. Formic acid poisoning in a tertiary care center in South India: A 2-year retrospective analysis of clinical profile and predictors of mortality. J Emerg Med 2013;44:373-80.
8. Rajan N, Rahim R, Krishna Kumar S. Formic acid poisoning with suicidal intent: A report of 53 cases. Postgrad Med J 1985;61:35-6.
9. Formic Acid (FAO Nutrition Meetings Report Series 38A). Available from: Availble from: https://inchem.org/documents/jecfa/jecmono/v38aje03.htm. [Last accessed on 2023 Oct 16].
10. Sujisha SS, Rema P, Sarathkumar A. Systemic effects and medicolegal aspects of formic acid poisoning - An autopsy study. J Evolution Med Dent Sci 2020;9:2166-70. [doi: 10.14260/jemds/2020/472].
11. Sabeerali HP, Prasad K. Formic acid poisoning the vital role of endoscopy in assessment and follow-up, case report. Curr Med Issues 2019;17:38-41.
12. Sabna PP, Valliyot B, Balakrishnan S. Acute formic acid poisoning: analysis of 60 cases from North Kerala. Int J Sci Res 2016;5:166-8.
13. Bingham E, Cohrssen B, Patty FA. Patty's Toxicology, 6 Volume Set, 6th Edition. Wiley, A John Wiley & Sons, Inc; 2012.
14. Jacobsen D, Ovrebø S, Sejersted OM. Toxicokinetics of formate during hemodialysis. Acta Med Scand 1983;214:409-12.
15. Moore DF, Bentley AM, Dawling S, Hoare AM, Henry JA. Folinic acid and enhanced renal elimination in formic acid intoxication. J Toxicol Clin Toxicol 1994;32:199-204.
16. Kapur BM, Vandenbroucke AC, Adamchik Y, Lehotay DC, Carlen PL. Formic acid, a novel metabolite of chronic ethanol abuse, causes neurotoxicity, which is prevented by folic acid. Alcohol Clin Exp Res 2007;31:2114-20.
17. Jones DP, Thor H, Andersson B, Orrenius S. Detoxification reactions in isolated hepatocytes. Role of glutathione peroxidase, catalase, and formaldehyde dehydrogenase in reactions relating to N-demethylation by the cytochrome P-450 system. J Biol Chem 1978;253:6031-7.
18. Lambeth J, Somasundaram K. Pyloric obstruction due to formic acid ingestion. Med J Malaya 1970;24:187-9.
19. Osamu and Kanako (2005). *Drugs and poisons in humans: A handbook of practical analysis*. Springer Heidelberg.doi: 10.1007/3-540-27579-7.
20. The International Association of Forensic Toxicologists. 40th International Meeting – August 26-30, 2002. Paris, France: Toxicologie Analytique et Clinique; 2002.
21. Goutham MK, Ravishankara S, Naik SM, Sathya P, Appaji M, Bhatt S. Acute formic acid poisoning: A case series analysis with current management protocols and review of literature. Otolaryngol Online J 2015;5:28-38.