ORIGINAL RESEARCH

Deliberate Self-poisoning due to Plant Toxins: Verdant Footprints of the Past into the Present

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Abstract

Background: Plant poisoning is one of the common methods of deliberate self-poisoning (DSP). Exposure to plants and its consequence account for a considerable number of deaths in rural India.

Materials and methods: This retrospective observational study was conducted in the emergency department of a large tertiary care hospital in South India over a period of 2 years and recruited patients who presented with DSP from plant poisoning.

Results: During the study period, 150 cases of plant poisoning were included. The mean (standard deviation) age of presentation was 31.4 (12.2) years. The most common type of plant poison consumed was oleander (63%) followed by oduvanthalai (50%), *Strychnos nux-vomica* (3%), datura (3%), and others, which comprised about 5.3% included henna (1.3%), cactus (1.3%), and a case each of castor, *Gloriosa superba, Adenanthera pavonina,* and *Abrus precatorius*. Patients in age-group 16–30 years had the highest rate of ingestion. The seasonal pattern was found to peak in the month of April. Gastric lavage was done in 102/150:68%. Consumption of decoction [odds ratio (OR): 5, 95% confidence interval (CI): 2.27–14.00, *p* value: <0.001] and metabolic acidosis (pH <7.35) (OR: 11.48, 95% CI: 4.17–31.57, *p* value: <0.001) were more common in oduvanthalai poisoning as compared to oleander. The mortality among plant poisoning was 9.3% (14/150).

Conclusion: Our study sheds light on the spectrum of local plants consumed for DSP. Oleander and oduvanthalai were most commonly used for DSP. Consuming a decoction of leaves leading to severe metabolic acidosis at presentation is seen associated with oduvanthalai poisoning.

Keywords: Deliberate self-poisoning, Emergency department, Oduvanthalai, Oleander, Plant poisons.

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Short Key Messages

Our study shows the spectrum of plants being consumed for deliberate self-harm in our locality in South India, with oleander and oduvanthalai being the most common. The highly toxic decoction being the preferred mode of consumption of oduvanthalai is the cause of concern. Our study highlights the clinical- and laboratory-distinguishing features between oleander and oduvanthalai poisoning with the latter presenting with significant metabolic acidosis.

Introduction

Deliberate self-poisoning (DSP) is a common presentation to an emergency department (ED). In low-middle-income countries like India where socioeconomic factors, such as poverty, unemployment, and domestic violence are pervasive, it is not surprising to find a higher prevalence of self-poisoning as opposed to psychiatric conditions in the west.[1-3] Such cases of nonfatal DSP account for 10.6/100,000 in the Indian subcontinent, almost ranking the highest in the world, with an estimated 50,000 deaths per year.[2] Various methods of DSP as seen in another study done in South India are ingestion of agrochemicals, plant poisons, rodenticides, and drugs.[4]

The local availability of highly toxic plants predominantly in the rural areas of an agrarian society like India only provides an easy access to self-poisoning. A deadly combination of low intention, high lethality, and lack of proper medical infrastructure poses a risk of severe mortality. In India, there are more than 4,000 species of medicinal plants growing as herbs, shrubs, and trees, many of which are used in traditional medicine by local apothecaries to make potions for various ailments.[5,6] These medicinal plants are usually seen as cohabitants with many toxic plants, usually flowering shrubs and herbs, commonly used as ornamental plants around houses and temples. A lack of knowledge or, perhaps, the knowledge of the constituents can prove to be fatal when used in large doses. The ingestion of medicinal compounds in large doses can be fatal as most of them believe it to be particularly safe because of their natural origin.[7] The toxicological patterns of plants used for DSP vary according to the culture, availability, and geographical locations around the world. In spite of the high prevalence of DSP using plant poisons, a few studies are undertaken to understand the

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patterns involved in such cases. Hence, this study was undertaken in Vellore, a town in Southern India, to study the incidence and the toxicological profile of these patients.

Materials and Methods

Study Design

This was a retrospective study on patients presenting with plant poisoning.

Study Setting

The study was conducted in the ED of a large tertiary care hospital in South India. Our ED is a 50-bed department and tends to have about 300 patients per day including toxicology and other cases.

Participants

All patients with plant toxin ingestion who presented to the ED between January 2017 and December 2018.

Inclusion Criteria

Patients with DSP with plant or plant products/plant toxins were included in the analysis.

Exclusion Criteria

DSP due to other causes and patients with missing data and brought dead were excluded from the analysis.

Variables

Patient data were retrieved through the ED triage registry software and the hospital electronic database. The variables included were age, sex, mode of DSP, methods of ingestion, factors triggering DSP, associated risk factors suggestive of known psychiatric illness and previous history of DSP, and details of prehospital and ED resuscitation.

Outcome Variables

The outcome measures were the spectrum of compounds/method of DSP and factors associated with oleander and oduvanthalai poisoning along with inhospital mortality.

Bias

This is a retrospective cohort study, and therefore we could not control exposure-outcome assessment, and instead relied on others for accurate record keeping.

Statistical Analysis

The analysis was done using Statistical Package for Social Sciences for Windows (SPSS Inc., released 2015, version 23.0. Armonk, New York, USA). Continuous variables are presented as mean (standard deviation [SD]). Categorical and nominal variables are presented as percentages. Bivariate analysis and their 95% confidence intervals were calculated. For all tests, a 2-sided *p* value less than 0.05 was considered statistically significant.

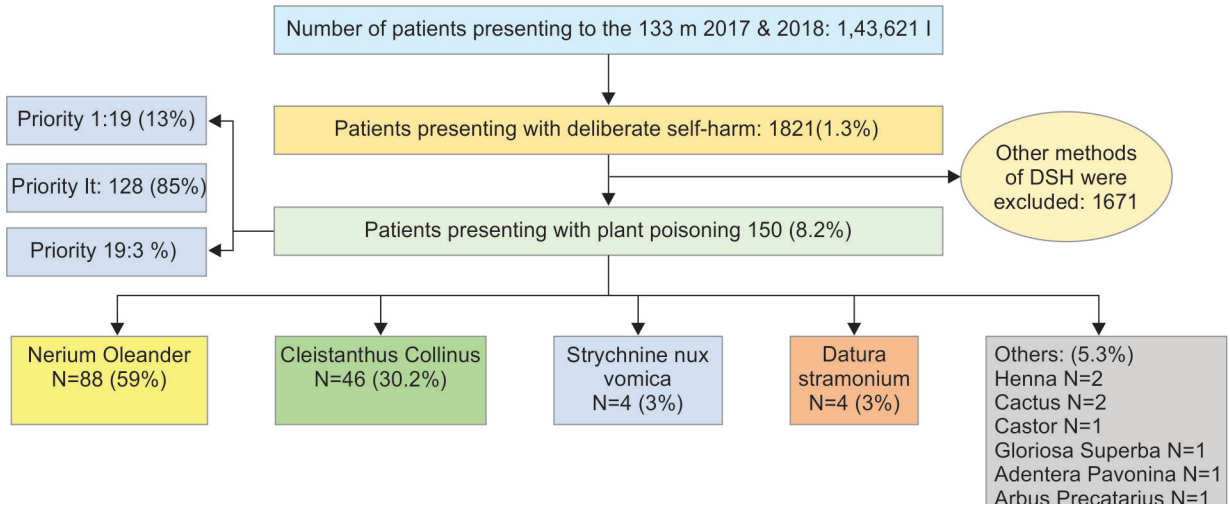
Ethical Considerations

The study was approved by the institutional review board (IRB min. no. 12269 dated 09/25/2019) and patient confidentiality was maintained by using unique identifiers and by password-protected data entry software with restricted uses.

Results

During the study period from January 2017 to December 2018, the ED triaged 1,43,621 patients, of which 1,821 patients (1.3%) presented with DSP and deliberate self-harm (DSH). Of these, 150 patients (8.2%) presented with plant poisoning (Flowchart 1). The major plant poison compounds ingested were oleander (57/150:59%), oduvanthalai (46/150:30.7%), *Strychnos nux-vomica* (4/150:3%), datura (4/150:3%), and others which comprised about 5.3% included henna (1.3%), cactus (1.3%), and a case each of castor, *Gloriosa superba, Adenanthera pavonina,* and *Abrus precatorius*. The various methods of ingestion were crushed/ground seeds (49%) and a decoction of leaves (28%) followed by crushed/ground leaves (27%) and chewing and swallowing (9%). A gender ratio of 90:60 (female:male) with a female predominance of 60% was seen. The mean age (SD) was 31.4 (12.2) years. The majority, i.e., 85% (128/150) were triaged as priority II based on our ED triage guidelines. About 87% (131/150) of the affected population arrived at ED after more than 2 hours of ingestion of toxic compounds.

Flowchart 1: STROBE diagram



A vast majority, i.e., 80% (120/150) of them were referred from other local health facilities. Previous history of DSP was seen in nine patients (6%) of the population. Those under the influence of alcohol accounted for up to 5.3% (8/150) (Table 1). As for the most common plant poison is consumed by females, the first position is occupied by oleander (63%) closely followed by oduvanthalai (50%). The age-group that succumbed to the most to this vice was 16 to 30 years (Fig. 1). A seasonal pattern with an increasing trend in the month of April was observed (Fig. 2). In our study, 48% (72/150) of those who consumed plant poisons attributed it to domestic violence. The other triggers seen were unknown (48/150:32%) followed by personal (9/150:0.06%), relationship (7/150:0.04%), financial (6/150:0.04%), health (4/150:0.02%), and workplace issues (4/150:0.02%). The most common presentation at ED was tachycardia, seen in 31% (47/150), and tachypnea in 39% (59/150). Emergency decontamination and resuscitation measures employed were gastric lavage in 68% (102/150) and temporary pacemaker implantation in 33% (49/150), respectively (Table 1). Only eight (5.3%) of them were discharged stable from ED while 121 (81%) of them required inhospital admission. The inhospital mortality rate was 9.3% (14/150); however, 27 patients (18%) left the hospital against medical advice. The mortality among plant poison was 9.3% (14/150) (Fig. 3). Consumption of decoction [odds ratio (OR): 5, 95% confidence interval (CI): 2.27–14.00, *p* value: <0.001] and metabolic acidosis (pH <7.35) (OR: 11.48, 95% CI: 4.17–31.57, *p* value: <0.001) were more common in oduvanthalai poisoning as compared to oleander (Table 2).

Table 1: Baseline demographics (*N* = 150), severity of presentation to ED

Characteristics	*Number (%)*
Mean age (SD)	31.4 (12.2)
Female	90 (60)
Referred from another hospital	120 (80)
Time of presentation to the ED	
<2 hours	19 (13)
>2 hours	131 (87)
Mean time gap (SD)	15.5 (25.4)
Associated risk factors	
K/C/O psychiatric illness	1 (0.6)
Previous DSH history	9 (6)
Under the influence of alcohol	8 (5.3)
Severity at presentation to ED	
Tachycardia (HR >100 beats/min)	47 (31)
Bradycardia (HR <60 beats/min)	9 (6)
Tachypnea (RR >22/min)	59 (39)
Systolic blood pressure (SBP ≤90 mm Hg)	24 (16)
SpO_2 <94%	16 (11)
Low sensorium	8 (5.3)
ED resuscitation	
Gastric lavage	102 (68)
Cardiac arrest in the ED	3 (2)
ED intubation	12 (8)
Inotropes in ED	7 (5)
Temporary pacemaker implantation	49 (33)

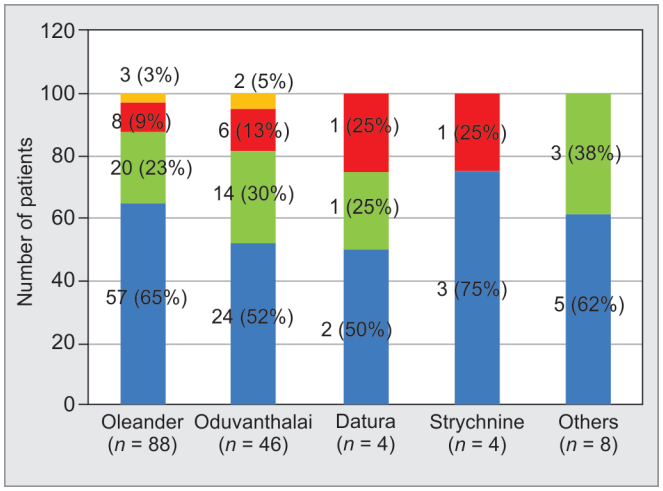


Fig. 1: Age-group distribution

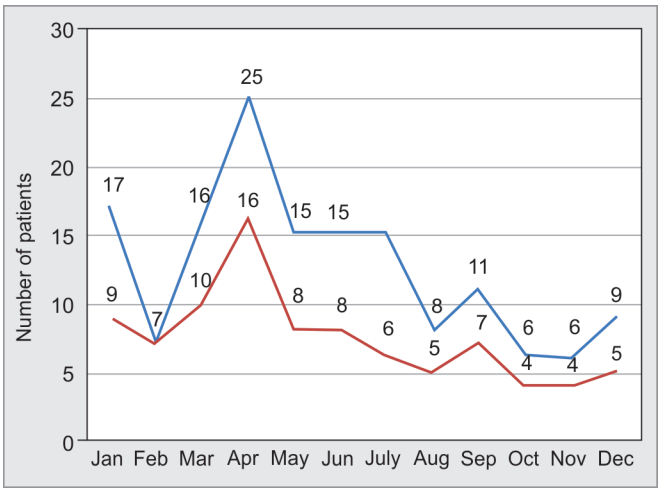


Fig. 2: Seasonal pattern in DSP with plant poisons

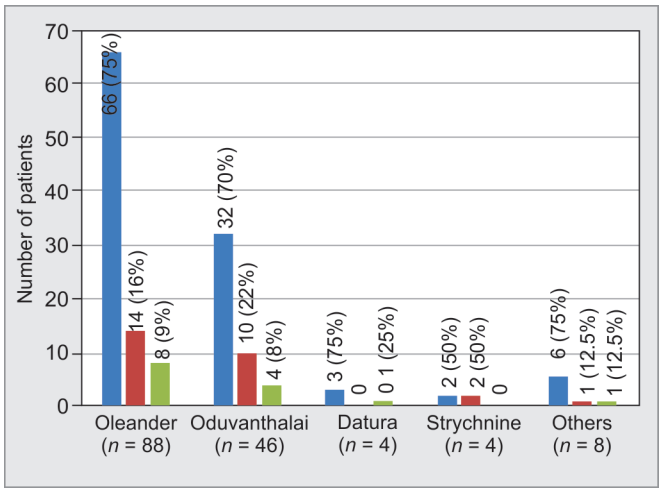


Fig. 3: ED and hospital outcome

Table 2: Bivariate analysis of factors associated with oleander and oduvanthalai poisoning

	Oleander	*Oduvanthalai*	*Bivariate analysis*	
Variable	*N = 88*	*N = 46*	*p value*	*OR (95% CI)*
Age <30 years	57 (64.8%)	24 (52.2%)	0.19	1.68 (0.81–3.48)
Decoction	9 (10.2%)	18 (39.1%)	<0.001	5 (2.27–14.00)
Systolic BP <100 mm Hg	18 (20.5%)	6 (13%)	0.35	1.71 (0.63–4.67)
Heart rate >100 bpm	22 (25%)	15 (32.6%)	0.42	0.69 (0.32–1.51)
Heart rate <60 beats/min	8 (9.1%)	1 (2.2%)	0.16	4.5 (0.55–37.14)
pH <7.35	6 (6.8%)	21 (45.7%)	<0.001	11.48 (4.17–31.57)
K <3.5 mEq/L	18 (20.9%)	17 (37.8%)	0.06	0.44 (0.19–0.96)
K >4.5 mEq/L	7 (8.1%)	7 (15.6%)	0.24	0.48 (0.16–1.47)
HCO_3 <18 mmol/L	28 (32.6%)	31 (68.9%)	<0.001	4.58 (2.11–9.96)
Pacemaker implantation	31 (35.2%)	18 (39.1%)	0.71	0.84 (0.41–1.76)
Mortality	8 (9.1%)	4 (8.7%)	1	1.05 (0.29–3.69)

Discussion

Our study shows the spectrum of common plants that are seen in our geographic locality with the most common being yellow oleander (*Thevetia peruviana*) and *Cleistanthus collinus*, known as oduvanthalai (nillipalai). Other key findings of our study were younger group being victims of DSP with this method associated with a high mortality rate (9.3%). Consumption of decoction and metabolic acidosis (pH <7.35) were more common in oduvanthalai poisoning as compared to oleander.

The assortment of plant used for DSP in our geographic locality was very different from that seen in rural Sri Lanka where *Jatropha curcas* (Barbados nut/physic nut/poison nut) followed by *T. peruviana* (oleander) and *A. precatorius* (rosary pea/paternoster pea/wild licorice) were the most common plant poisons in vogue,[8] hence the need for adequate knowledge of geotoxinology for providing quality emergency management in such cases.

The World Health Organization categorizes DSH as a form of "parasuicide." Parasuicide is defined as "an act with a nonfatal outcome in which an individual deliberately initiates a nonhabitual behavior, that without intervention from others will cause self-harm, or deliberately ingests a substance in excess of the prescribed or generally recognized dosage, and which is aimed at realizing changes that the person desires via the actual or expected physical consequences."[9] DSP using plant poisons continues to be a significant cause of DSP in rural India. In our study, about a tenth of the DSP cases that presented to the ED were related to ingestion of plant products, with a female prevalence as seen in most of other studies.[1,2] This could be attributed to domestic violence, the emotional status of young girls, and their vulnerability during the pubertal years. Many of these plants including datura, oleander, aconite, and nux vomica are easily available as wild shrubs growing alongside roads, rivers, and canals in many parts of the world.[5,9] The toxic principles in these plants belong to alkaloids, glycosides, toxalbumins, resins, cannabinoids, and polypeptides.

In our study, most of these incidents were seen in the young age-group of 16 to 30 years as seen in the rest of the world.[1,2] Increased incidence of intentional poisoning could have an increasing trend due to peer pressures, relationship issues, and unwarranted parental expectations to perform well at school. Knowledge of the availability of native plants and their common clinical presentations are of paramount importance to the medical personnel in that area for proper management of such DSP incidents.

Oleander (*T. peruviana*)

More than half of our study population chose oleander as the plant poison of choice. Studded with beautifully colored flowers, this tree is usually seen as a household ornamental in many places in India. Of the various species of the Apocynaceae family locally seen, the yellow oleander is the most toxic. The household availability of these plants makes them the most common method of DSP. Yellow oleander seeds contain highly toxic cardiac glycosides including vetins A and B and neriifolin. All parts of the plant including nectar are poisonous. The toxic principles are cardiac glycosides similar to digoxin. They are oleandrin, oleandrigenin, and oleandroside.[10] Various methods of ingestion include eating the flowers, sucking the nectar, and chewing the stems or the leaves.

Various cardiac dysrhythmias and dyselectrolytemia are the most common complications.[11] An imbalance in the active transport of sodium and calcium ions across cardiac myocytes is responsible for severe cardiac arrhythmias. Severe bradycardia leading to cardiogenic shock is the cause of death. Gastric lavage with activated charcoal, cardiac monitoring for tachy- and brady-arrhythmias with adequate intravenous fluids, and correction of hyperkalemia with probable temporary cardiac pacing are the principles of symptomatic treatment. Calcium gluconate is contraindicated in the management of hyperkalemia due to cardiac arrhythmias. The cause of death is usually myocardial depression, leading to cardiogenic shock. The inhospital mortality (11%) of our study is comparable to 10% in a study done in Sri Lanka.[12] Specific antibodies, such as digoxin-specific antigen-binding fragment (Fab), have been successfully used in adult patients, albeit their lack of availability in India restricts their usage.[13-15] The prohibitively expensive nature of the drug hampers its availability and usage in emergency management in countries like India which perhaps has the highest prevalence of such cases.

Oduvanthalai (*C. collinus*)

Our study population shows the popular usage of oduvanthalai in about one-third of them with an inhospital mortality of 11%. A species of the Euphorbiaceae family, this deciduous shrub is wildly found in the tropics. Although described in other tropical regions like Malaysia and Africa, deliberate ingestion of this toxin is commonly seen only in parts of southern India.[16] Ingestion of this plant poison is favored by many young women in Tamil Nadu and Pondicherry due to its easy availability and open access.[16] All parts of the plant are toxic with cleistanthin and cleistanthin B (glycosides) and diphyllin (arylnaphthalene lignan lactones) as the major toxic principles. Various modes of consumption include swallowing the crushed plant parts, ingestion of juice/paste of the plant parts, or a decoction of leaves in boiling water. Boiling of leaves increases the bioavailability of the toxin, causing serious consequences.[17] The toxidrome includes life-threatening cardiac, electrolyte, and

acid-base disturbances. At presentation, gastrointestinal symptoms are predominant followed by dyselectrolytemia, mainly severe hypokalemia with normal anion gap metabolic acidosis. Distal renal tubular acidosis due to toxin-mediated inhibition of the vacuolar H+ATPase activity in the renal brush border membrane appears to be the underlying mechanism of injury. Decreased glomerular filtration rate and global tubular dysfunction are also seen in severe cases.[18] The cause of death appears to be due to intractable metabolic acidosis and hypokalemia, leading to neuromuscular blockade and type 2 respiratory failure.

Cardiac abnormalities are also associated with *Cleistanthus* poisoning. Bradycardia with electrocardiogram changes, such as prolonged QTc, inverted T-waves, and depressed ST segment are seen in about 95% of the cases.[16] Gastric lavage, correction of dyselectrolytemia, fluid resuscitation, and cardiac monitoring appear to be the mainstay of management.

Datura (*Datura stramonium*)

As seen in our study, DSP with datura is comparatively on the lower side with only four cases (3%) preferring it for intentional poisoning with no inhospital mortality. With large, erect, trumpet-like white flowers and spiny, round seedpods, the thorn apple or the devil's trumpet, is a toxic shrub, belonging to the family Solanaceae. The widespread availability of these plants makes it an effortless method of DSP hidden in plain sight. This plant is a common favorite in traditional medicine, sacred rituals, and folklore. The toxic principles include the highly toxic anticholinergic tropane alkaloids, such as atropine and scopolamine.[19] The seeds are particularly toxic, even in small quantities, although deliberate ingestion of all other plant parts has also been attributed to lethal complications. The toxidrome includes the classic signs of anticholinergic toxicity, such as red as a beet, dry as a bone, hot as a hare, blind as a bat, mad as a hatter, and full as a flask. Conservative methods of treatment, such as gastric lavage and supportive measures, are indicated.

Nux vomica (*S. nux-vomica*)

Owing to its bitter taste and the ability of easy detection, this method of DSP was only employed by four patients in our study with no inhospital mortality. The brown colored, discoid seeds of this tree contain highly toxic, bitter alkaloids, such as strychnine and brucine, which were originally used as arrowhead poisons. This tree, native to the deciduous regions of India and Southeast Asia, with its sprawling green cover, provides shade in open habitats. Commonly known as "*Azraqi*" in oriental Unani medicine, this plant of the Loganiaceae family is known to be a deadly poison, even in minute quantities. The detoxified remnants of this plant product have been used in traditional medicine since time immemorial. Various case reports depict the toxidrome of this toxin including opisthotonus, severe metabolic acidosis, hyperthermia, and rhabdomyolysis with renal failure, culminating in respiratory failure, leading to death.[7] This is a direct result of excitation of all portions of the central nervous system by an increase in the neuronal excitability as a result of selectively blocked inhibition. With such a dramatic mode of death, this compound was usually implicated in suspicious homicides in the literature.[20] Diazepam was seen to be useful in controlling the convulsions as it acts specifically to decrease the inhibitory mechanisms released by strychnine.[21]

Clinical Implication

Our study has described the spectrum of plant poisons, their clinical presentations, and modes of treatment of those plants that are commonly consumed for DSP in the Southern part of Tamil Nadu. Clinicians working in similar settings should be aware of such emergencies and be prepared to provide adequate care. Plant poisons as a cause of DSP had a high mortality rate of 9.3%. Multiple strategies can be employed to reduce deaths in this population, which happen to be the working section of the society. Restricting access to such plants is the limiting factor since these plants are easily available in household gardens and by the roadside.

Research Implication

We found an association between drinking a decoction of leaves of oduvanthalai poisoning and increased toxicity. Future research should be focused on the detailed pathophysiology and toxicity of these plants. Despite having a significant number of cases, an effective antidote for oleander poisoning is still not available in India and the "digoxin-specific Fab antibody fragments" are prohibitively expensive. Hence, research on developing an alternate affordable antidote for oleander poisoning is the urgent need of the hour in developing countries like India. Another potential area of future research is determining the indications and usefulness of "prophylactic pacemaker" for oleander poisoning, which at the moment is inconclusive.

Strengths and Limitations

This study is one of its kind studies conducted in South India where data on common plant poisons used for DSP and their modes of presentation were collected. However, the tertiary nature of our hospital is an inherent bias in population selection and may not truly represent the community prevalence of DSH due to plant poisoning.

Conclusion

In our study, the most common plant poisons which were associated with significant mortality were oleander and oduvanthalai. Consuming a decoction of leaves leading to severe metabolic acidosis at presentation is seen associated with oduvanthalai poisoning. It is imperative for local authorities to restrict easy access to these lethal plants to decrease the incidence of plant poisoning. All physicians working in emergency settings should be aware of the initial management of the most common poisons in that region and their acute management.

Research Quality and Ethics Statement

The authors of this manuscript declare that this scientific work complies with reporting quality, formatting, and reproducibility guidelines set forth by the EQUATOR Network. The authors also attest that this clinical investigation was determined to require institutional review board/ethics committee review, and the corresponding protocol/approval number is IRB min. no. 12269 dated 09/25/2019. We also certify that we have not plagiarized the contents in this submission and have done a plagiarism check.

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