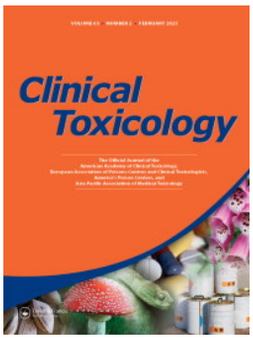

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SHORT COMMUNICATION

Comparison of children receiving extracorporeal treatments for poisoning at United States centers with and without a pediatric nephrologist

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ABSTRACT

Background: Pediatric nephrologists are rare in the United States; many children with poisoning needing extracorporeal treatments may not have timely access to care. This study compared outcomes in children receiving extracorporeal treatments for poisoning at centers with and without a pediatric nephrologist.

Methods: This was a retrospective cohort study of all patients aged ≤17 years reported to an American poison center covering three upper midwestern states during 2000–2024.

Results: We identified 72 patients: 54 received extracorporeal treatments at a hospital with pediatric nephrologists, and 18 patients aged 14–17 years (minimum weight, 35 kg) received extracorporeal treatments at hospitals staffed solely by adult nephrologists. The most common responsible poisons were toxic alcohols (10/18, 55%) and salicylates (4/18, 22%). Children receiving extracorporeal treatments from adult nephrologists more commonly ($P<0.001$) received intermittent hemodialysis (18/18, 100%) compared to pediatric nephrologists (31/54, 57%). Conversely, children treated by pediatric nephrologists more commonly ($P<0.05$) received continuous kidney replacement therapy (28/54, 52%) compared to adult nephrologists (0/18). We found no difference ($P=0.1$) in mortality between the children treated by pediatric nephrologists (9/54, 17%) compared to those treated by adult nephrologists (0/18).

Discussion: Teenage children commonly received hemodialysis from adult nephrologists for poisoning and had similar outcomes to those treated by pediatric nephrologists.

Conclusions: These data suggest adult nephrologists can successfully perform extracorporeal treatments for poisoning in teenage children.

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Continuous kidney replacement therapy; extracorporeal treatment; hemodialysis; pediatrics; poisoning; salicylates

Introduction

Extracorporeal treatments for blood purification, such as intermittent hemodialysis and continuous kidney replacement therapy, are well-described and common treatments for poisoning in adults but not in children [1]. In 2022, of the 2,476 patients who received hemodialysis for poisoning reported to the National Poison Data System®, 2,335 were ≥20 years old, and only 13 patients were under the age of 13 years [2].

Furthermore, pediatric nephrologists themselves are uncommon and tend to work solely at highly specialized centers. Since 1974, only 1,199 pediatricians in the United States have been certified by the American Board of Pediatrics in nephrology; in contrast, the current estimated United States adult nephrology workforce is over 30,000 physicians [3].

While small children have unique needs related to hemodialysis, including properly sized equipment and unique physiologic considerations, older children anatomically resemble adults and may be amenable to receiving hemodialysis from adult nephrologists [4]. As timely access to pediatric nephrologists is frequently limited, the purpose of this study was to compare outcomes in children receiving extracorporeal treatments for poisoning at centers with and without a pediatric nephrologist.

Methods

This was a retrospective cohort study of all patients aged ≤17 years receiving extracorporeal treatments reported to an American poison center covering three upper midwestern states from 2000-2024. We identified all cases in the electronic medical record (ToxiCALL®, version 4.7.40, Computer Automation Systems, Inc., Aurora, CO) of this poison center in which "hemodialysis," "continuous renal replacement therapy," "hemoperfusion," and "plasmapheresis" were coded as "performed." Our institutional review board approved this study.

In our three-state region, pediatric nephrologists practice inpatient medicine at only five hospitals. Accordingly, cases were classified as having access to pediatric nephrology only if extracorporeal treatments occurred at one of these facilities; all other cases were classified as extracorporeal treatments from adult nephrologists. Five-digit ZIP codes for

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extracorporeal treatment sites were geospatially mapped using ArcGIS (Esri Inc. 2021. Redlands, CA: Esri™).

Standard National Poison Data System® outcomes are reported. Descriptive statistics characterized findings (Microsoft Excel, v.2023). Differences between groups were evaluated using Mann-Whitney U and Fisher's exact tests as appropriate.

Results

We enrolled 72 patients: 16 received extracorporeal treatments from 2000 to 2009, 22 from 2010 to 2017, and 34 from 2018 to 2024. Fifty-four children (75%) received extracorporeal treatments at hospitals with pediatric nephrologists. Eighteen children (25%) received extracorporeal treatments at hospitals staffed solely by adult nephrologists; hospital records were available for nine cases, all of which confirmed adult nephrology management. These 18 children had higher ($P=0.26$) median weights (72 kg) than the 54 treated by pediatric nephrologists (52 kg) and comprised 32% (18/56) of all children aged 14–17 years. All children aged ≤13 years received extracorporeal treatments from pediatric nephrologists. Fifty-five children were transferred from their initial healthcare facility; of these, 14 were transferred to a facility staffed only by adult nephrologists.

Children receiving extracorporeal treatments from adult nephrologists more commonly ($P<0.001$) received intermittent hemodialysis (18/18) compared to those treated by pediatric nephrologists (31/54, 57%). Conversely, children treated by pediatric nephrologists more commonly ($P<0.05$) received continuous kidney replacement therapy (28/54, 52%) compared to those treated by adult nephrologists (0/18). Concomitant vasopressors (29/54, 54%) and endotracheal intubation (40/54, 74%) were more common ($P<0.001$) in children treated by pediatric nephrologists than those treated by adult nephrologists: 1/18 [6%] and 5/18 [28%], respectively. However, we found no difference ($P=0.1$) in mortality: 9/54 (17%) versus 0/18, respectively.

Demographics, concomitant therapies, and outcomes are reported in Table 1. Figure 1 displays children receiving extracorporeal treatments for poisoning by ZIP code. Cases were clustered in three metropolitan areas; children were treated by adult and pediatric nephrologists in two of three clusters.

Discussion

Among children with poisoning ages 14-17 years requiring extracorporeal treatments, nearly one-third were treated at hospitals staffed exclusively by adult nephrologists. Poisoning was most commonly due to intentional ingestion and involved poisons commonly treated with hemodialysis in adults [5–7]. Children dialyzed by adult nephrologists did not have worse outcomes.

Unsurprisingly, we found children dialyzed by adult nephrologists were comparable to adults with respect to body weight. We also found they were more likely to receive intermittent hemodialysis, which is generally the preferred modality in poisoning due to higher clearance rates [5]. This proclivity for pediatric nephrologists to choose intermittent hemodialysis less commonly is likely due to physiologic and anatomic differences in small children related to extracorporeal treatments. Hemodialysis is more technically difficult in smaller children due to their smaller total blood volumes

Table 1. Demographics, concomitant therapies, and clinical outcomes in 72 patients who received extracorporeal treatments for poisoning.

Variables	Pediatric nephrology group (*n* = 54)		Adult nephrology group (*n* = 18)		Entire cohort (*n* = 72)	
Age (years)						
≤5 years, *n* (%)	12	(22)	0		12	(17)
6–12 years, *n* (%)	2	(4)	0		2	(3)
13–17 years, *n* (%)	40	(74)	18	(100)	58	(80)
Weight (kg), median (range)	52	(6.2–100)	72	(35–107)	63	(6.2–107)
Reason for exposure						
Intentional suspected suicide, *n* (%)	31	(57)	13	(72)	44	(61)
Unintentional general, *n* (%)	8	(15)	3	(17)	11	(15)
Intentional misuse, *n* (%)	2	(4)	0		2	(3)
Adverse drug reaction, *n* (%)	1	(2)	0		1	(1)
Malicious, *n* (%)	1	(2)	0		1	(1)
Other withdrawal, *n* (%)	1	(2)	0		1	(1)
Unknown, *n* (%)	10		2		12	
Route of exposure[a]						
Ingestion, *n* (%)	52	(96)	18	(100)	70	(97)
Unknown, *n* (%)	2		0		2	
Single substance cases, *n* (%)	34	(63)	11	(61)	45	(63)
Most common poisons						
Ethylene glycol, *n* (%)	8	(15)	7	(44)	15	(21)
Salicylates, *n* (%)	7	(13)	4	(22)	11	(15)
Paracetamol, *n* (%)	8	(15)	0		8	(11)
Lithium, *n* (%)	5	(9)	1	(6)	6	(8)
Methanol, *n* (%)	3	(5)	3	(17)	6	(8)
Metformin, *n* (%)	3	(5)	0		3	(4)
Others, *n* (%)	20	(37)	3	(17)	23	(32)
Related clinical effects						
Acidosis, *n* (%)	30	(55)	10	(56)	40	(55)
Cardiac arrest, *n* (%)	3	(5)	0		3	(4)
Serum creatinine concentration increased, *n* (%)	19	(35)	4	(22)	23	(32)
Electrolyte abnormalities, *n* (%)	18	(33)	1	(6)	19	(26)
Oliguria/anuria, *n* (%)	13	(24)	3	(17)	16	(22)
Osmol gap increased, *n* (%)	1	(2)	2	(11)	3	(4)
Kidney failure, *n* (%)	14	(26)	3	(17)	17	(24)
Extracorporeal treatment modalities						
Hemodialysis, *n* (%)	31	(57)	18	(100)	49	(68)
Continuous kidney replacement therapy[b], *n* (%)	28	(52)	0		28	(39)
Plasmapheresis, *n* (%)	2	(4)	0		2	(3)
Hemoperfusion, *n* (%)	0		1	(6)	1	(1)
Other therapies						
Ventilator and/or endotracheal intubation, *n* (%)	40	(74)	5	(28)	45	(62)
Urine alkalinization, *n* (%)	29	(54)	8	(44)	37	(51)
Vasopressors, *n* (%)	29	(54)	1	(6)	30	(42)
Fomepizole, *n* (%)	13	(24)	9	(50)	21	(29)
Blood products, *n* (%)	7	(13)	0		7	(10)
Extracorporeal membrane oxygenation, *n* (%)	7	(13)	0		7	(10)
Cardiopulmonary resuscitation, *n* (%)	4	(7)	1	(6)	5	(7)
Medical outcome						
Moderate, *n* (%)	7	(13)	8	(44)	15	(21)
Major, *n* (%)	31	(57)	8	(44)	39	(54)
Death, *n* (%)	9	(17)	0		9	(12)

[a]Six patients had one other route of exposure in addition to ingestion.
[b]Seventeen patients received extracorporeal treatments at a facility with pediatric nephrology at which only continuous kidney replacement therapy (i.e., not intermittent hemodialysis) was available.

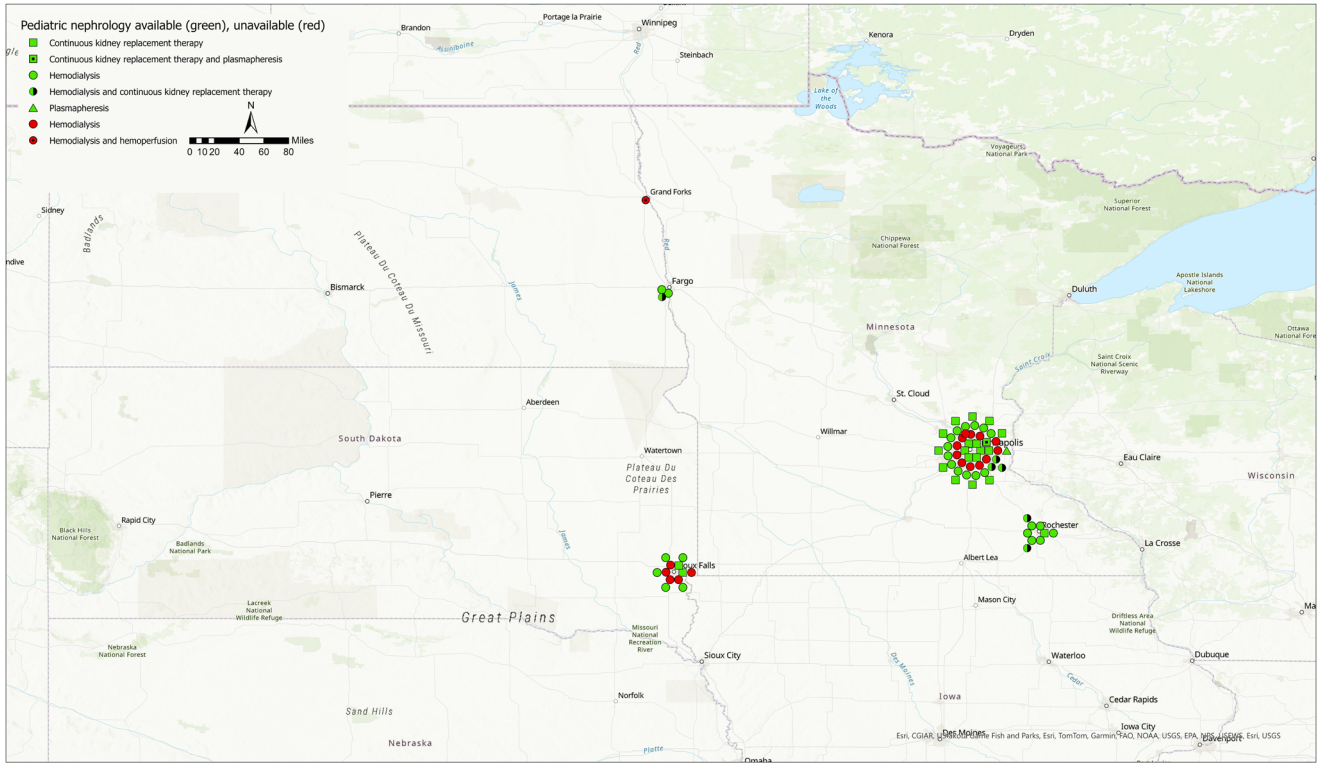

Figure 1. Geospatial mapping by United States ZIP code of the location where extracorporeal treatments for poisoning were performed for all children ≤17 years of age during 2000–2024. Children receiving extracorporeal treatments at hospitals staffed solely by adult nephrologists are represented by red shapes; children dialyzed at hospitals with pediatric nephrology available are represented by green shapes.

relative to extracorporeal blood volume requirements [8]. Blood flow rates, and therefore clearance rates, can also be limited by the smaller catheters required of young children resulting in longer treatment durations and more frequent use of continuous renal replacement therapy.

Pediatric nephrologists are scarce; about 500 currently practice in the United States [9]. If a pediatric nephrologist is unavailable in a timely manner, our data suggest larger children can be safely dialyzed in an adult dialysis center.

Hospital privileging is a challenge that may be encountered in such cases. Adult nephrologists may not have hospital privileges specifically allowing for dialyzing children. Although adult nephrologists may believe they can safely provide hemodialysis to larger children, they may be hesitant to do so due to perceived risks of adverse actions from hospital credentialing committees, or perceived medicolegal risk. However, in a true emergency in which the life of a patient is in immediate danger, medical staff bylaws typically maintain provisions indicating physicians acting within the scope of their professional license shall be permitted to do anything possible, regardless of clinical privileges, to save the life of a patient. It is likely some cases in this study met that criteria.

This study has several limitations, including the usual inaccuracies in poison center studies [10]. For example, because it is a poison center-based study, hospital records were not uniformly available to confirm if adult nephrologists were definitively providing extracorporeal treatments. We believe this possibility is low, however, given the limited availability of pediatric nephrologists and because, in half of our cases, available hospital records confirmed the involvement of adult nephrologists. Our study is also limited by its relatively small sample size, given how infrequent hemodialysis is needed in poisoned children.

Conclusion

We found that children aged 14-17 years commonly received extracorporeal treatments for poisoning from adult nephrologists and had similar outcomes to children treated by pediatric nephrologists. These data suggest that adult nephrologists can successfully perform extracorporeal treatments for poisoning in teenage children.

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Data availability statement

Data available on request due to privacy/ethical restrictions

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