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RESEARCH ARTICLE

Prevalence of secondary arterial hypertension in patients with acute renal failure in a secondary-level pediatric hospital in Northwestern Mexico

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Abstract

Background: *The worldwide prevalence of arterial hypertension in pediatric patients is 3.5%, and it has repercussions at renal, cardiovascular, neurological, and lifestyle levels. This study aimed to estimate the prevalence of arterial hypertension, mortality, and follow-up in patients with acute renal failure in the nephrology outpatient clinic at a second-level hospital in Northwestern Mexico.* **Methods:** *We conducted a descriptive, retrospective, and observational study. Men and women aged 1-18 years diagnosed with acute kidney injury were analyzed from January 1, 2012, to December 31, 2021. The medical and electronic records of the candidate patients were analyzed, and nutritional data, laboratory analysis, most frequent etiology, and follow-up in the pediatric nephrology clinic were collected. Those with exacerbated chronic kidney disease and previous diagnosis of high blood pressure were excluded.* **Results:** *One hundred and seventy-four patients were evaluated, and only 40 were eligible for the study (22.98%), predominantly males with a mean age of 9.9 years. The degree of arterial hypertension was 50% for grade I and 50% for grade II (p = 0.007); the mortality rate was 32%. One hundred percent of hypertension cases were controlled at 6 months after discharge (p = 0.000080).* **Conclusions:** *Our results were similar to those reported in other studies. Follow-up and early detection of arterial hypertension in children need to be strengthened.*

Keywords: *Hypertension. Acute renal failure. Pediatrics.*

Prevalencia de hipertensión arterial secundaria en pacientes con insuficiencia renal aguda en un hospital pediátrico de II nivel en el Noroeste de México

Resumen

Introducción: *La prevalencia de hipertensión arterial a nivel mundial es 3.5% en los pacientes pediátricos y tiene repercusiones tanto a nivel renal, cardiovascular, neurológico y estilo de vida. El objetivo de este estudio fue estimar la prevalencia de hipertensión arterial en pacientes con insuficiencia renal aguda, estimar la mortalidad y el seguimiento de los pacientes en la consulta externa de nefrología en un hospital de segundo nivel en el Noroeste de México.* **Métodos:** *Estudio observacional descriptivo, retrospectivo. Se analizaron hombres y mujeres entre 1 a 18 años de edad con el diagnóstico de lesión renal aguda, entre 1 de enero del 2012 hasta 31 de diciembre del 2021. Se analizaron las historias clínicas y el expediente electrónico de los pacientes candidatos, se recolectaron datos nutricionales, análisis de laboratorio, etiología más frecuente*

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y el seguimiento en la consulta de nefrología pediátrica. Se excluyeron aquellos con enfermedad renal crónica agudizada y diagnóstico previo de hipertensión arterial. **Resultados:** *174 pacientes fueron evaluados y solamente 40 fueron candidatos al estudio (22.98%), de los cuales predominaron masculinos con una edad media de 9.9 años. El grado de hipertensión arterial fue 50% para grado I y 50% para grado II (p = 0.007); tasa de mortalidad 32%. El 100% del control de la hipertensión se logró en el seguimiento del egreso de los pacientes en 6 meses (p = 0.000080).* **Conclusiones:** *Nuestros resultados fueron similares a los reportados en otros estudios. Se debe reforzar el seguimiento y detección oportuna de hipertensión arterial en los niños.*

Palabras clave: *Hipertensión arterial. Insuficiencia renal aguda. Pediatría.*

Introduction

The global prevalence of hypertension is approximately 3.5%, increasing with age to reach 18% among young adults. Blood pressure (BP) in children varies based on age, sex, and height. Hypertension, a condition characterized by advancements in etiology, definition, management, and prevention, exhibits an estimated prevalence of 3-5% in the United States, potentially higher among specific ethnic groups such as African Americans, Mexicans, and Hispanics. Reports indicate a prevalence of up to 10% in certain isolated geographic areas, and for individuals with obesity, rates can climb to 11%. A 2014 study by the National Institute of Pediatrics in Mexico found that among patients with hypertension, 92% (35 patients) had a history of kidney disease, including 34.3% with chronic kidney disease and 25.7% with acute renal failure, underscoring hypertension's role as a frequent complication of acute kidney injury (AKI). In 2001, at the Central Hospital of the Social Security Institute in Paraguay, out of 520 nephrology patients, 62 experienced acute renal failure, accounting for 12% of the cohort. Hypertension is defined as BP at or above the 95th percentile, confirmed by two measurements taken 3 min apart. It is classified into two categories: grade I (at or above the 95th percentile up to 12 mmHg above or between 130/80 and 139/89) and grade II (above the 95th percentile by more than 12 mmHg or ≥ 140/90)[1].

One of the most extensive epidemiological studies to date, the RICARDIN study collected data from over 11,000 adolescents across 10 centers in Spain. They found a hypertension prevalence of approximately 3%, a figure that could rise to 5%[2,3].

A retrospective cohort study was carried out in two pediatric centers in Montreal, Canada, focusing on children (≤ 18 years) admitted to the pediatric intensive care unit (ICU) from 2003 to 2010. The study included 1,978 patients with a median age at admission of 4.3 years (interquartile range: 1.1-11.8), 44% of whom were female. Of these, 325 (16.4%) developed AKI[4].

A systematic review spanning 1990-2014 was conducted using databases such as PubMed, African Journals Online, the World Health Organization (WHO), Global Health Library, and the Web of Science. This review aimed to assess the outcomes of AKI. In Sub-Saharan Africa, the severity of the disease was notable, with 1,042 (66%) of 1,572 children and 178 (70%) of 253 adults, requiring dialysis. Overall mortality rates were 34% in children and 32% in adults[5].

The relationship between AKI and increased BP remains uncertain. To explore this, a retrospective cohort study assessed whether hospital-acquired AKI was independently associated with an elevation in BP during the first 2 years post-discharge among previously normotensive adults. This study was conducted in collaboration with Kaiser Northern California and Stanford University School of Medicine, Stanford. According to multivariate models, AKI was independently associated with a 22% increase (95% confidence interval: 12-33%) in the likelihood of elevated BP[6].

The clinical manifestations of hypertension are often asymptomatic, but when symptoms do occur, they are generally non-specific and can include headaches, epistaxis, visual disturbances, facial paralysis, polyuria, polydipsia, and failure to thrive among others. In cases of severe hypertension, known as a hypertensive crisis, it can impact target organs, leading to conditions such as left ventricular hypertrophy and congestive heart failure, as well as microalbuminuria, proteinuria, and renal failure[2].

AKI is characterized by a sudden loss or a decrease in kidney function, resulting in the body's inability to maintain homeostasis. This condition is typically indicated by an increase in the serum concentration of nitrogenous waste products, adjusted for age and sex, as shown in table 1, along with reduced urine output and glomerular filtration rate (GFR)[5]. The RIFLE classification, according to the Acute Dialysis Quality Initiative[7], categorizes the severity of AKI based on the increase in creatinine levels.

Table 1. AKIN classification 2007

Stage	Serum creatinine	Urine output
I	1.5-1.9 times baseline or ≥ 0.3 mg/dL increase	< 0.5 mL/kg/h for 6-12 h
II	2-3 times baseline	< 0.5 mL/kg/h for 12 h
III	> 3 times baseline or > 4 mg/dL or > 0.5 mg/dL increase or Initiation of renal replacement therapy	< 0.3 mL/kg/h for ≥ 24 h or anuria for ≥ 12 h

The primary complications arising from AKI include hypertension due to volume overload, metabolic acidosis, hyponatremia, hyperkalemia, hypocalcemia, and hyperphosphatemia. Hypertension in the context of AKI is primarily attributed to volume overload. The preferred treatment involves the administration of diuretics, specifically furosemide, which is effective when the creatinine clearance rate is below 50 ml/min/1.73 m[2-7].

It has been demonstrated that, in hospitalized children, AKI is associated with an increased requirement for mechanical ventilation, prolonged hospital and ICU stays, and elevated mortality rates[8]. In our region, an updated prevalence of arterial hypertension is lacking. Consequently, the primary objective of this study was to estimate the prevalence of arterial hypertension in patients with acute renal failure. Secondary objectives included the identification of clinical characteristics, etiology, mortality rates, and follow-up outcomes among children in Culiacan, Sinaloa. We hypothesized that the prevalence would be higher compared to other regions, secondary to more timely detection.

Methods

A cross-sectional study was conducted, gathering information from the medical records of children attended in the emergency room (ER) (for both consultation and hospitalization) and the hospitalization wards (internal medicine, surgery, oncology, infectious diseases, gastroenterology, and intensive care) at a secondary-level hospital in Culiacan, Sinaloa. Records from January 2012 to December 2021 were reviewed.

Eligibility criteria included clinical records of children who attended the ER and were hospitalized with BP above the 95^{th} percentile for age, height, and sex during episodes of acute renal failure. Exclusion criteria encompassed children with acute-on-chronic kidney disease, a previous diagnosis of arterial hypertension, and those younger than 1 year. Exclusion criteria were incomplete data in the clinical history and record.

The clinical history served as a measurement tool, indirectly providing sociodemographic data (such as sex, age, and height) and information on nutritional status. In addition, BP measurement was assessed. Analyses included the GFR, urine output, plasma creatinine, complete blood count, serum electrolytes, arterial blood gases, comorbidities, antihypertensive treatment, and hypertension control at 6 months post-discharge in the nephrology outpatient clinic. Serum electrolytes and arterial blood gases were also evaluated to determine the correlation between the findings and existing medical literature in the selected patients.

The AKI Network 2007 classification was utilized for AKI classification in pediatric patients. BP monitoring involves measurements at home or the nearest in case of not having the necessary material for the measurement. In this case, a stethoscope and a manual sphygmomanometer were required. Measurements were taken 3 times weekly and at follow-up consultations, avoiding stimulants or caffeine, with the patient seated for a minimum of 5 min.

The measurement of creatinine by the laboratory was validated using isotope dilution mass spectrometry, standardized as the reference method. The formula employed to estimate the GFR was based on the updated Schwartz equation from 2009, which is defined as $GFR = K \times \frac{height}{CrP}$ (with height in meters, K as a constant of 0.413 for children aged 1 year to adolescence, and CrP as plasma creatinine).

For the quantification of proteinuria, it was essential to collect a 24-h urine sample the day before the patient's follow-up visit to pediatric nephrology. Proteinuria levels were classified as nephrotic with > 1 g/m^2/day and non-nephrotic when they were between 100 and 1,000 mg/m^2/day.

The outcome variable, the persistence of arterial hypertension, was assessed according to age, sex, and height, evaluated by the attending physician and nurse during hospital admission, and recorded in the section corresponding to the diagnosis. The diagnosis documented in the medical records was determined based on criteria from the WHO and the American Academy of Pediatrics, as detailed in tables 1-3.

Data processing was conducted automatically through the SPSS version 25.0 system, with data entry

Table 2. Blood pressure percentiles for males according to age and height

Age (years)	Percentiles (Height)	Systolic BP by height percentile							Diastolic BP by height percentile						
		P5	P10	P25	P50	P75	P90	P95	P5	P10	P25	P50	P75	P90	P95
1	50th	80	81	83	85	87	88	89	34	35	36	37	38	39	39
	90th	94	95	97	99	100	102	103	49	50	51	52	53	53	54
	95th	98	99	101	103	104	106	106	54	54	55	56	57	58	58
	99th	105	106	108	110	112	113	114	61	62	63	64	65	66	66
2	50th	84	85	87	88	90	92	92	39	40	41	42	43	44	44
	90th	97	99	100	102	104	105	106	54	55	56	57	58	58	59
	95th	101	102	104	106	108	109	110	59	59	60	61	62	63	63
	99th	109	110	111	113	115	117	117	66	67	68	69	70	71	71
3	50th	86	87	89	91	93	94	95	44	44	45	46	47	48	48
	90th	100	101	103	105	107	108	109	59	59	60	61	62	63	63
	95th	104	105	107	109	110	112	113	63	63	64	65	66	67	67
	99th	111	112	114	116	118	119	120	71	71	72	73	74	75	75
4	50th	88	89	91	93	95	96	97	47	48	49	50	51	51	52
	90th	102	103	105	107	109	110	111	62	63	64	65	66	66	67
	95th	106	107	109	111	112	114	115	66	67	68	69	71	71	71
	99th	113	114	116	118	120	121	122	74	75	76	77	78	78	79
5	50th	90	91	93	95	96	98	98	50	51	52	53	54	55	55
	90th	104	105	106	108	110	111	112	65	66	67	68	69	69	70
	95th	108	109	110	112	115	115	116	69	70	71	72	73	74	74
	99th	115	116	118	120	123	123	123	77	78	79	80	81	81	82
6	50th	91	92	94	96	98	99	100	53	53	54	55	56	57	57
	90th	105	106	108	110	111	113	113	68	68	69	70	71	72	72
	95th	109	110	112	114	115	117	117	72	72	73	74	75	76	76
	99th	116	117	119	121	123	124	125	80	80	81	82	83	84	84
7	50th	93	93	95	96	97	99	99	55	56	56	57	58	58	59
	90th	106	107	108	109	111	112	113	69	70	70	71	72	72	73
	95th	110	111	112	113	115	116	116	73	74	74	75	76	76	77
	99th	117	118	119	120	122	123	124	81	81	82	82	83	84	84
8	50th	95	95	96	98	99	100	101	57	57	57	58	59	60	60
	90th	108	109	110	111	113	114	114	71	71	71	72	73	74	74
	95th	112	112	114	115	116	118	118	75	75	75	76	77	78	78
	99th	119	120	121	122	123	125	125	82	82	83	83	84	85	86
9	50th	96	97	98	100	101	102	103	58	58	58	59	60	61	61
	90th	110	110	112	113	114	116	116	72	72	72	73	74	75	75
	95th	114	114	115	117	118	119	120	76	76	76	77	78	79	79
	99th	121	121	123	124	125	127	127	83	83	84	84	85	86	87
10	50th	98	99	100	102	103	104	105	59	59	59	60	61	62	62
	90th	112	112	114	115	116	118	118	73	73	73	74	75	76	76
	95th	116	116	117	119	120	121	122	77	77	77	78	79	80	80
	99th	123	123	125	126	127	129	129	84	84	85	86	86	87	88
11	50th	100	101	102	103	105	106	107	60	60	60	61	62	63	63
	90th	114	114	116	117	118	119	120	74	74	74	75	76	77	77
	95th	118	118	119	121	122	123	124	78	78	78	79	80	81	81
	99th	125	125	126	128	129	130	131	85	85	86	87	87	88	89
12	50th	102	103	104	105	107	108	109	61	61	61	62	63	64	64
	90th	116	116	117	119	120	121	122	75	75	75	76	77	78	78
	95th	119	120	121	123	124	125	126	79	79	79	80	81	82	82
	99th	127	127	128	130	131	132	133	86	86	87	88	88	89	90
13	50th	104	105	106	107	109	110	110	62	62	62	63	64	65	65
	90th	117	118	119	121	122	123	124	76	76	76	77	78	79	79
	95th	121	122	123	124	126	127	128	80	80	80	81	82	83	83
	99th	128	129	130	132	133	134	135	87	87	88	89	89	90	91

(Continues)

Table 2. Blood pressure percentiles for males according to age and height *(continued)*

Age (years)	Percentiles (Height)	Systolic BP by height percentile							Diastolic BP by height percentile						
		P5	P10	P25	P50	P75	P90	P95	P5	P10	P25	P50	P75	P90	P95
14	50th	106	106	107	109	110	111	112	63	63	63	64	65	66	66
	90th	119	120	121	122	124	125	125	77	77	77	78	79	80	80
	95th	123	123	125	126	127	129	129	81	81	81	82	83	84	84
	99th	130	131	132	133	135	136	129	88	88	89	90	90	91	92
15	50th	109	110	112	113	115	117	117	61	62	63	64	65	66	66
	90th	122	124	125	127	129	130	131	76	77	78	79	80	80	81
	95th	126	127	129	131	133	134	135	81	81	82	83	85	85	85
	99th	134	135	136	138	140	142	142	88	89	90	91	93	93	93
16	50th	111	112	114	116	118	119	120	63	63	64	65	66	67	67
	90th	125	126	128	130	131	133	134	78	78	79	80	81	82	82
	95th	129	130	132	134	135	137	137	82	83	83	84	85	86	87
	99th	136	137	139	141	143	144	145	90	90	90	92	93	94	94
17	50th	114	115	116	118	120	121	122	65	66	66	67	68	69	70
	90th	127	128	130	132	134	135	136	80	81	81	82	83	84	84
	95th	131	132	134	136	138	139	140	84	85	86	87	87	88	89
	99th	139	140	141	143	145	146	147	92	93	93	94	95	96	97

Table 3. Blood pressure percentiles for females according to age and height

Age (years)	Percentiles (Height)	Systolic BP by height percentile							Diastolic BP by height percentile						
		P5	P10	P25	P50	P75	P90	P95	P5	P10	P25	P50	P75	P90	P95
1	50th	83	84	85	86	88	89	90	38	39	39	40	41	41	42
	90th	97	97	98	100	101	102	103	52	53	53	54	55	55	56
	95th	100	101	102	104	105	106	107	56	57	57	58	59	59	60
	99th	108	108	109	111	112	113	114	64	64	65	65	66	67	67
2	50th	85	85	87	88	89	91	91	43	44	44	45	46	46	47
	90th	98	99	100	101	103	104	105	57	58	58	59	60	61	61
	95th	102	103	104	105	107	108	109	61	62	62	63	64	65	65
	99th	109	110	111	112	114	115	116	69	69	70	70	71	72	72
3	50th	86	87	88	89	91	92	93	47	48	48	49	50	50	51
	90th	100	100	102	103	104	106	106	61	62	62	63	64	64	65
	95th	104	104	105	107	108	109	110	65	66	66	67	68	68	69
	99th	111	111	113	114	115	116	117	73	73	74	74	75	76	76
4	50th	88	88	90	91	92	94	94	50	50	51	52	52	53	54
	90th	101	102	103	104	106	107	108	64	64	65	66	67	67	68
	95th	105	106	107	108	110	111	112	68	68	69	70	71	71	72
	99th	112	113	114	115	117	118	119	76	76	76	77	78	79	79
5	50th	89	90	91	93	94	95	96	52	53	53	54	55	55	56
	90th	103	103	105	106	107	109	109	66	67	67	68	69	69	70
	95th	107	107	108	110	111	112	113	70	71	71	72	73	73	74
	99th	114	114	116	117	118	120	120	78	78	79	79	80	81	81
6	50th	91	92	93	94	96	97	98	54	54	55	56	56	57	58
	90th	104	105	106	108	109	110	111	68	68	69	70	70	71	72
	95th	108	109	110	111	113	114	115	72	72	73	74	74	75	76
	99th	115	116	117	119	120	121	122	80	80	80	81	82	83	83
7	50th	93	93	95	96	97	99	99	55	56	56	57	58	58	59
	90th	106	107	108	109	111	112	113	69	70	70	71	72	72	73
	95th	110	111	112	113	115	116	116	73	74	74	75	76	76	77
	99th	117	118	119	120	122	123	124	81	81	82	82	83	84	84

(Continues)

Table 3. Blood pressure percentiles for females according to age and height *(continued)*

Age (years)	Percentiles (Height)	Systolic BP by height percentile							Diastolic BP by height percentile						
		P5	P10	P25	P50	P75	P90	P95	P5	P10	P25	P50	P75	P90	P95
8	50th	95	95	96	98	99	100	101	57	57	57	58	59	60	60
	90th	108	109	110	111	113	114	114	71	71	71	72	73	74	74
	95th	112	112	114	115	116	118	118	75	75	75	76	77	78	78
	99th	119	120	121	122	123	125	124	82	82	83	83	84	85	86
9	50th	96	97	98	100	101	102	103	58	58	58	59	60	61	61
	90th	110	110	112	113	114	116	116	72	72	72	73	74	75	75
	95th	114	114	115	117	118	119	120	76	76	76	77	78	79	79
	99th	121	121	123	124	125	127	127	83	83	84	84	85	86	87
10	50th	98	99	100	102	103	104	105	59	59	59	60	61	62	62
	90th	112	112	114	115	116	118	118	73	73	73	74	75	76	76
	95th	116	116	117	119	120	121	122	77	77	77	78	79	80	80
	99th	123	123	125	126	127	129	129	84	84	85	86	86	87	88
11	50th	100	101	102	103	105	106	107	60	60	60	61	62	63	63
	90th	114	114	116	117	118	119	120	74	74	74	75	76	77	77
	95th	118	118	119	121	122	123	124	78	78	78	79	80	81	81
	99th	125	125	126	128	129	130	131	85	85	86	87	87	88	89
12	50th	102	103	104	105	107	108	109	61	61	61	62	63	64	64
	90th	116	116	117	119	120	121	122	75	75	75	76	77	78	78
	95th	119	120	121	123	124	125	126	79	79	79	80	81	82	82
	99th	127	127	128	130	131	132	133	86	87	87	88	88	89	90
13	50th	104	105	106	107	109	110	110	62	62	62	63	64	65	65
	90th	117	118	119	121	122	123	124	76	76	76	77	78	79	79
	95th	121	122	123	124	126	127	128	80	80	80	81	82	83	83
	99th	128	129	130	132	133	134	135	87	87	88	89	89	90	91
14	50th	106	106	107	109	110	111	112	63	63	63	64	65	66	66
	90th	119	120	121	122	124	125	125	77	77	77	78	79	80	80
	95th	123	123	125	126	127	129	129	81	81	81	82	83	84	84
	99th	130	131	132	133	135	136	136	88	88	89	90	90	91	92
15	50th	107	108	109	110	111	113	113	64	64	64	65	66	67	67
	90th	120	121	122	123	125	126	127	78	78	78	79	80	81	81
	95th	124	125	126	127	129	130	131	82	82	82	83	84	85	85
	99th	131	132	133	134	136	137	138	89	89	90	91	91	92	93
16	50th	108	108	110	111	112	114	114	64	64	65	66	66	67	68
	90th	121	122	123	124	126	127	128	78	78	79	80	81	81	82
	95th	125	126	127	128	130	131	132	82	82	83	84	85	85	86
	99th	132	133	134	135	137	138	139	90	90	90	91	92	93	93
17	50th	108	109	110	111	113	114	115	64	65	65	66	67	67	68
	90th	122	122	123	125	126	127	128	78	79	79	80	81	81	82
	95th	125	126	127	129	130	131	132	82	83	83	84	85	85	86
	99th	133	133	134	136	137	138	139	90	90	91	91	92	93	93

performed twice to minimize typographical errors. For statistical analysis, absolute numbers and percentages were utilized as summary measures.

A statistical method was applied that began with a descriptive analysis to identify the frequencies of the variables using cross tables. Pearson's χ^2 was calculated to evaluate the association between variables; p lower than 0.05 would indicate a significant sensitivity analysis. To manage missing data, we resorted to complementary information from progress notes and contributions from parents, physicians, and nurses. The main purpose of this analysis was to establish a significant relationship between the variables studied, focusing on the statistical significance of these associations. The research protocol was approved by the teaching coordination of the *Hospital Pediátrico de Sinaloa "Rigoberto Aguilar Pico,"* located in Culiacán, Sinaloa. Emphasis was placed on the exclusive use of primary records already existing in the clinical files, always guaranteeing the confidentiality and anonymity of the patients involved.

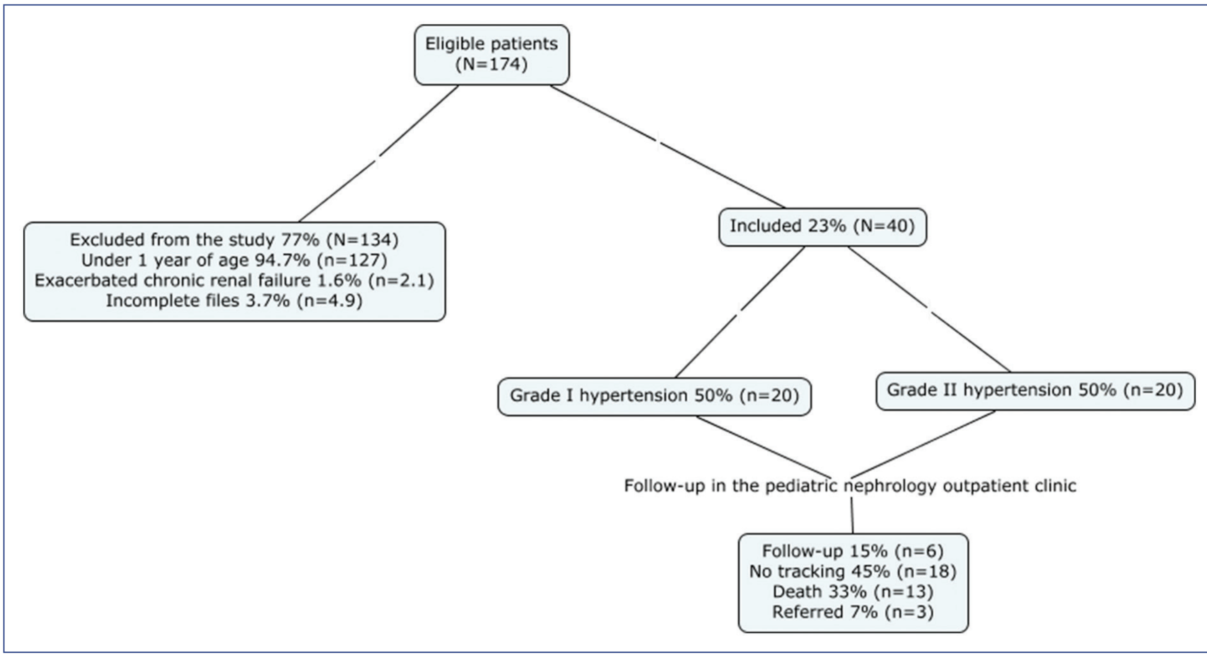

Figure 1. Flowchart.

Results

Figure 1 illustrates the flowchart of the analysis conducted on 174 medical records of children treated over the past 9 years. Of these, 134 cases were discarded; 94.7% were due to the patients being under 1 year of age, 1.6% because of exacerbated chronic renal failure, and 3.7% were removed due to insufficient information in the file and from the parents.

Among the 174 patients assessed, 22.98% (n = 40) experienced hypertension during their hospitalization. Fifty percent had grade I hypertension and 50% grade II, with a χ^2 p-value of 0.007, which is significant.

In terms of the patients' nutritional status, 60% (n = 26) (p = 0.492) were found to have adequate nutrition for their age and sex. As for the severity of the acute renal failure, 62.5% (n = 25) were classified as grade III (Table 4), a result that was not statistically significant.

The primary clinical and laboratory findings included: 55% (n = 22) had diuresis within the normal range for their age, 72.5% (n = 29) exhibited normochromic normocytic anemia, 47.5% (n = 19) (p = 0.749) had leukocyte counts within the normal range, 65% (n = 26) (p = 0.740) experienced thrombocytopenia, 60% (n = 24) (p = 0.702) had normal sodium levels, 62.5% (n = 25) (p = 0.413) showed normochloremia, 65% (n = 26) (p = 0.777) maintained potassium within normal limits, 80% (n = 32) (p = 0.358) had phosphorus within normal limits, 65% (n = 26) (p = 0.916) had glucose levels within normal parameters, and 27.5% (n = 11) (p = 0.231)

Table 4. Clinical characteristics of patients included in the study, complete group

Variables	Patients with acute renal failure 100% (n = 40)	p*-value
Hypertension	Normotensive 77.02% (134) Hypertensive 22.98% (40)	N/A
Hypertension stage	Stage I 50% (20) Stage II 50% (20)	0.007
Sex	Male 60% (24) Female 40% (16)	0.384
Age	Older infants 12.5% (5) Pre-school 10% (4) Schoolage 32.5% (13) Teenager 45% (18)	0.284
Nutritional condition	Average 65% (26) Mild malnutrition 5% (2) Moderate malnutrition 2.5% (1) Severe malnutrition 10% (4) Overweight 7.5% (3) Obesity 10% (4)	0.492
Renal failure stage	Stage I 12.5% (5) Stage II 25% (10) Stage III 62.5% (25)	N/A

*Pearson's χ^2.

Table 5. Clinical characteristics of the patients included in the study (follow-up)

Variables	Patients with acute renal failure 100% (n = 40)	p*-value
Diuresis	Average 55% (22) Oliguria 20% (8) Polyuria 5% (2) Anuria 20% (8)	0.071
Hemoglobin	Normal 27.5% (11) Anemia 72.5% (29)	0.749
Leukocytes	Average 47.5% (19) Leukocytosis 27.5% (11) Leukopenia 25% (10)	0.740
Platelets	Average 35% (14) Thrombocytopenia 65% (26)	0.053
Sodium	Average 60% (24) Hypernatremia 7.5% (3) Hyponatremia 32.5% (13)	0.702
Chlorine	Average 62.5% (25) Hyperchloremia 37.5% (15)	0.413
Potassium	Average 65% (26) Hyperkalemia 20% (8) Hypokalemia 15% (6)	0.777
Phosphorus	Average 80% (32) Hyperphosphatemia 17.5% (7) Hypophosphatemia 2.5% (1)	0.358
Glucose	Average 65% (26) Hyperglycemia 35% (14)	0.916
Blood gas	Metabolic acidosis 27.5% (11)	0.231

*Pearson's χ^2.

suffered from metabolic acidosis. None of these findings were statistically significant (Table 5).

Regarding cardiovascular manifestations, 85% (n = 34) (p = 0.338) of the patients showed no alterations, and 5% (n = 2) showed pleural effusion. Neurological assessments revealed no alterations in 77.5% (n = 31) (p = 0.466), and 17.5% (n = 7) appearing drowsy. Renally, 42.5% of the patients (n = 17) (p = 0.231) showed no alterations, with 20% (n = 8) experiencing metabolic acidosis, and 10% (n = 4) showing pallor and anasarca. Finally, among gastrointestinal manifestations, 65% of the patients (n = 26) (p = 0.934) had no alterations, 15% (n = 6) reported abdominal pain, and 10% (n = 4) experienced hematemesis (Supplementary table 1). All reported data were not statistically significant.

At the time of discharge, 65% (n = 26) of the 40 patients included in the study were under control, whereas 36% exhibited persistent arterial hypertension. These findings were not statistically significant, with a p-value of 0.517. The mortality rate stood at 32% (13 patients), with the highest prevalence in the 12-17-year age group (20%).

The primary causes of AKI were renal in 92.5% of cases. Septic shock was identified in 35% (n = 14) of cases, tumor lysis syndrome in 7.5% (n = 3), combined septic and hypovolemic shock in 5% (n = 2), and septic shock with cardiogenic shock also in 5% (n = 2). At the pre-renal level, hypovolemic shock accounted for 2.5% (n = 1), and post-renal, neurogenic bladder was identified in 5% (n = 2) (Table 6). None of these findings were statistically significant, with a p-value of 0.520.

Table 7 reveals the relationship between the control of arterial hypertension and follow-up in nephrology consultations, indicating that 100% (n = 6) of the patients who achieved control of arterial pressure demonstrated statistically significant outcomes, with a p-value of 0.000080.

Table 8 presents data on proteinuria from follow-up visits at the nephrology outpatient clinic, showing that 33.3% (n = 2 patients) had proteinuria in the non-nephrotic range and 50% (n = 3 patients) exhibited no proteinuria. This was statistically significant, with a p-value of 0.050. Notably, all patients who attended the follow-up (six patients) did not present with hypertension.

Discussion

In this series, school children and adolescents predominated (77.5%). Furthermore, in an investigation conducted in an ICU in Canada, a predominance of acute renal failure in the male sex (60%) was detected, similar to this series. However, there were differences between the age groups (school children)[4].

The global prevalence of hypertension is 3.5% and increases with age to 18% in young adults. In Spain, it is around 3%. In the National Institute of Pediatrics in Mexico, in 2014, a prevalence study of hypertension associated with acute renal failure reported a rate of 25.7%. In our study, the rate was 22.98%, which is consistent[1]. Compared with the retrospective study in Canada, our study reported a higher incidence of hypertension with AKI (22.98%). On the other hand, 65% of patients had grade III renal failure, which has been linked to the presence of septic shock and tumor lysis syndrome, with underlying diseases including acute lymphoblastic leukemia, Burkitt's lymphoma, pyelonephritis, and acute appendicitis.

Regarding diagnosis, infectious diseases were significantly more frequent in the population with AKI,

Table 6. Description of pediatric patients according to their etiology

Classification (%)	Etiology 100% (n = 40)		p*-value
Pre-renal (2.5%)	Hypovolemic shock 2.5% (1)		0.520
Renal (92.5%)	Septic shock 35% (14) Tumor lysis syndrome 7.5% (3) Septic shock and hypovolemic shock 5% (2) Septic shock and cardiogenic shock 5% (2) Acyclovir tubulointerstitial nephritis 5% (2) PIMS 2.5% (1) Sepsis 2.5% (1) Sepsis and Tumor Lysis Syndrome 2.5% (1) Sepsis and rapidly progressive glomerulonephritis 2.5% (1) Hemolytic Uremic Syndrome 2.5% (1) Lupus nephropathy 2.5% (1) Post-Strep Glomerulonephritis 2.5% (1)	– Septic shock, multiple organ failure and arrest cardiorespiratory 2.5% (1) – Septic shock, Tumor lysis syndrome, and acidosis tube type 2.5% (1) – Septic shock and graft-versus-host disease 2.5% (1) – Cardiogenic shock 2.5% (1) – Drowning 2.5% (1) – IgA glomerulopathy 2.5% (1) – Multiple organ failure 2.5% (1)	
Post-renal (5%)	Neurogenic bladder 5% (2)		

*Pearson's χ^2.

Table 7. Follow-up of arterial hypertension

Follow-up in the Nephrology outpatient clinic (n = 6)	Arterial hypertension 100% (n = 6)		p*-value
Present	100% controlled (6)	Not controlled 0% (0)	0.000080

*Pearson's χ^2.

similar to the findings of Duzova et al., who observed ischemic injury (28%) and sepsis (18.2%)[9] in 472 patients with acute renal injury. Our study aligns with these findings, particularly with septic shock (Table 6).

During their hospital stay, 47% of the patients required management with vasopressors: vancomycin (52.5%), methotrexate (10%), non-steroidal anti-inflammatory drugs (17.5%), and steroids (70%), which have been associated with increased arterial hypertension, resulting in their limited use.

The treatment strategy focuses on therapeutic measures, generally consisting of correcting blood volume, water-electrolyte alterations, blood replacement, addressing the underlying cause, and employing dialysis methods. Early and efficient extrarenal clearance contributes to reduced mortality[10]. Renal replacement therapy should be initiated early, especially in certain cases of AKI (hemolytic uremic syndrome, tumor lysis, and post-operative cardiac conditions)[11-13]. In this series, both conventional hemodialysis and peritoneal dialysis were performed.

Another finding in our study was a lower in-hospital mortality rate in patients with acute renal failure (27%), compared to results reported by Touza et al., who recorded a mortality rate of 32.4% in 136 children admitted to a pediatric ICU[14].

According to Askenazi et al., between 34% and 50% of children who experienced acute kidney damage progressed to chronic renal failure during follow-up. This data supports the recommendation for prolonged follow-up in children who have suffered from acute kidney damage[15]. In our study, 17.5% (n = 13) attended their follow-up appointment at the pediatric nephrology outpatient clinic.

In the demographic characteristics of the patients included in the study, it was shown that 50% (n = 20) were from Culiacán, 10% (n = 4) from Navolato, 7.5% (n = 3) from Mazatlán and Cosala, and finally, 2.5% (n = 1) from Tijuana (Table 9). In addition, in the follow-up, only 15% (n = 6) attended: three patients were from Culiacán, and three patients were from Mazatlán, Navolato, and Guasave, respectively. None of the data obtained was statistically significant (p = 0.473).

Our study describes a relationship between follow-up in nephrology consultations and total BP control, underscoring the importance of proper referral to their follow-up appointment in nephrology. In the follow-up of our study, the development of proteinuria was observed in 33.3% of patients, which is the most significant isolated factor in determining the progression of kidney disease.

One limitation identified in this investigation was the lack of detailed BP characteristics recorded in the files.

Table 8. Relation of proteinuria during follow-up in the nephrology outpatient clinic

Follow-up in the Nephrology outpatient clinic (n = 6)	Proteinuria grade 100% (n = 6)				p*-value
Present	Yes 33.30% (2)	Not 50% (3)	Nephrotic range 0% (0)	With no laboratories 16.70% (1)	0.050

*Pearson's χ^2.

Table 9. Demographic characteristics of the patients included in the study

Municipalities	100% (n = 40)	Follow-up (with arterial hypertension) 0% (n = 0)	Follow-up (no high blood pressure) 100% (n = 6)	p*-value
Culiacán	50% (20)	0% (0)	50% (3)	0.473
Navolato	10% (4)	0% (0)	16.6% (1)	
Guasave	5% (2)	0% (0)	16.6% (1)	
Escuinapa	2.5% (1)	0% (0)	0% (0)	
Mazatlán	7.5% (3)	0% (0)	16.6% (1)	
Guamúchil	2.5% (1)	0% (0)	0% (0)	
Ahome	5% (2)	0% (0)	0% (0)	
Sinaloa of Leyva	2.5% (1)	0% (0)	0% (0)	
Mocorito	2.5% (1)	0% (0)	0% (0)	
Cosala	7.5% (3)	0% (0)	0% (0)	
Rosario	2.5% (1)	0% (0)	0% (0)	
Another state (Tijuana)	2.5% (1)	0% (0)	0% (0)	

*Pearson's χ^2.

Based on the data obtained from this study, it is crucial to continue with the timely detection of arterial hypertension due to its multiple repercussions in pediatric patients.

The prevalence of arterial hypertension in patients with renal failure was comparable to that reported in other studies. Therefore, strategies for timely detection and follow-up should be reinforced. These findings emphasize the importance of strict monitoring of kidney function, even in patients with no prior kidney disease but who have known risk factors for AKI due to their significant impact on life quality and function.

Conflicts of interest

The authors declare no conflicts of interest

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Ethical disclosures

Protection of human and animal subjects. The authors declare that no experiments were performed on humans or animals for this study. Confidentiality of data. The authors declare that they have followed the protocols of their work center on the publication of patient data.

Right to privacy and informed consent. The authors have obtained the written informed consent of the patients or subjects mentioned in the article. The corresponding author has this document.

Use of artificial intelligence for generating text. The authors declare that they have not used any type of generative artificial intelligence for the writing of this manuscript nor for the creation of images, graphics, tables, or their corresponding captions.

Supplementary material

Supplementary data are available at DOI: 10.24875/BMHIM.23000013. These data are provided by the corresponding author and published online for the benefit of the reader. The contents of supplementary data are the sole responsibility of the authors.

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