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Paediatric Hydrocephalus in Angola: Five-Year Outcomes and Complications Following Ventriculoperitoneal Shunt Surgery

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ABSTRACT

Introduction: Hydrocephalus is the most common neurosurgical condition of childhood, and ventriculoperitoneal (VP) shunt insertion remains its most widely used treatment. In Africa, the burden of disease is high, but published outcome data are scarce, particularly in Portuguese-speaking countries.

Objectives: To describe the paediatric population undergoing VP shunt insertion at the largest tertiary paediatric referral hospital in Angola and to report early and late complications, shunt revisions, and mortality.

Methods: Retrospective review of clinical records of children with hydrocephalus operated at a tertiary hospital in Luanda between 2021 and 2025. Records were curated (deduplication, normalisation of categorical fields, and grouping). Clinical variables and outcomes were described; associations were tested with the Mann-Whitney U test, the chi-square test, and Fisher's exact test, and with logistic regression when the events-per-variable ratio allowed.

Results: Of 455 records, 443 unique patients were analysed, 228 male (51.5%). Hydrocephalus was congenital in 99.8% and communicating in 95.5%. Median age at diagnosis was 14 days (interquartile range [IQR] 2–122) and at surgery 32 days (IQR 12–122). Myelomeningocele was recorded in 88 patients (19.9%), clubfoot in 33 (7.4%), and meningitis in 31 (7.0%). Early complications (<30 days) were recorded in 110 patients (24.8%), mainly meningitis (n=24; 5.4%) and catheter infection (n=22; 5.0%). Hospital mortality was 8.8% (n=39) and overall mortality (hospital or 30-day) 9.0% (n=40); only 3 patients (0.7%) required shunt revision. Complications

were associated with younger age at diagnosis (median 5 vs 22 days; $p=0.010$) and at surgery (24 vs 58 days; $p=0.021$). In univariable analysis, myelomeningocele was associated with complications (odds ratio [OR] 1.78; 95% CI 1.08–2.94; $p=0.029$); the association attenuated after adjustment (OR 1.60; 95% CI 0.94–2.74; $p=0.085$).

Conclusions: In this series, hospital mortality was 8.8% and about one quarter of children had early complications, predominantly meningitis and catheter infection. Short follow-up limits the estimation of revisions and long-term survival.

Keywords: hydrocephalus; ventriculoperitoneal shunt; postoperative complications; hospital mortality; infant; Angola

1. INTRODUCTION

Hydrocephalus is the abnormal accumulation of cerebrospinal fluid within the cerebral ventricles. Left untreated, it leads to impaired neurodevelopment, cognitive disability, and early death¹. Ventriculoperitoneal (VP) shunt insertion is the most commonly performed procedure for its treatment and one of the most frequent operations in paediatric neurosurgery worldwide^{1,2}. A systematic review estimated nearly 400 000 new cases of paediatric hydrocephalus each year, more than three quarters of them in low- and middle-income countries; the incidence of congenital hydrocephalus is higher in Africa and Latin America than in North America³.

In low- and middle-income countries, late presentation, a shortage of neurosurgeons, and the cost of shunt hardware limit access to treatment and influence outcomes^{4,5,6}. Aetiology also differs: in sub-Saharan Africa, postinfectious hydrocephalus is reported as the most common cause in several series^{7,8,9}, while neural tube defects, particularly myelomeningocele, remain an important and potentially preventable cause^{10,11,12}. Maternal supplementation and food fortification with folic acid reduce the incidence of these defects and constitute the main preventive measure available¹³.

Shunt surgery carries its own morbidity. Obstruction and infection are the most common modes of shunt failure, with failure rates in paediatric series of roughly 30–40% in the first year^{2,14,15}. Standardised perioperative protocols reduce shunt infection in high-income multicentre networks^{16,17,18}. Endoscopic third ventriculostomy with choroid plexus cauterization has been evaluated in African children with outcomes comparable to VP shunting in randomised trials and

large cohorts^{19,20,21,22,23}, although a multicentre trial found no benefit of endoscopic shunt insertion³¹. VP shunting remains the predominant option across the continent⁸.

The objective of this study was to describe the demographic and clinical characteristics, early and late complications, shunt revisions, and mortality of children with hydrocephalus treated with VP shunt insertion at a tertiary hospital in Luanda between 2021 and 2025, and to explore associations between clinical variables and outcomes.

2. MATERIALS AND METHODS

2.1. Design, setting, and participants

This was a single-centre retrospective observational study conducted in the Paediatric Neurosurgery Unit of Hospital Pediátrico David Bernardino, Angola's largest tertiary paediatric referral hospital, located in Luanda. The study included records of children diagnosed with hydrocephalus who underwent surgical treatment with ventriculoperitoneal (VP) shunt placement between 1 January 2021 and 31 December 2025. Duplicate records and records outside the study period were excluded.

2.2. Data curation

The electronic database, organised by year, was imported and curated before analysis. Deduplication was performed on a normalised patient name (removal of prefixes such as “RN” and “de”, and of accents); 24 records with repeated names were flagged and 12 duplicates (2.6% of the initial 455 records) were removed, leaving 443 unique patients. Categorical variables were normalised for spelling and accents (for example, “MALANGE” and “HAUAMBO” were standardised to Malanje and Huambo; “S/DVP”, “SEM/DVP”, and “S/ DVP” were treated as one category). Origin was grouped into “Luanda and adjacent municipalities” (Luanda, Icolo e Bengo, Cacuaco, Rangel) and “other provinces”. Comorbidities were extracted from free text using text patterns (myelomeningocele, clubfoot, meningitis, ventriculitis, sepsis). Free-text early complications were categorised into nine mutually exclusive classes by keyword.

2.3. Variables

The following data were recorded: sex, province of origin, type of health coverage, aetiology, type of hydrocephalus, age at diagnosis, age at surgery, operative time, head circumference at

diagnosis, initial imaging modality, antibiotic prophylaxis, comorbidities, early complication (<30 days), late complication (>30 days), shunt revision, hospital mortality, 30-day mortality, duration of follow-up, and loss to follow-up. The outcome “complication or revision” was defined as a recorded early or late complication or a shunt revision. The outcome “death” was defined as hospital or 30-day death.

2.4. Statistical analysis

Continuous variables are presented as median and interquartile range (IQR) because the distributions were skewed (Shapiro-Wilk test). Categorical variables are presented as frequency and percentage with 95% confidence intervals (CI) calculated using the Wilson method for the main outcomes. Two-group comparisons used the Mann-Whitney U test; contingency tables were analysed with the chi-square test or Fisher's exact test. Variation across years was assessed with the Kruskal-Wallis test. The association between myelomeningocele and complications was quantified by the odds ratio (OR) with 95% CI (Woolf method) and adjusted for sex, age at diagnosis, and age at surgery in a logistic regression model, respecting a minimum of 10 events per variable. The significance level was set at 0.05. Analyses were performed in Python (pandas, SciPy, and statsmodels).

2.5. Ethical considerations

Data were analysed anonymously. The study was conducted in accordance with the Declaration of Helsinki and was approved by the institutional ethics committee of Hospital Pediátrico David Bernardino (reference no. HP-DP 95/2026); the requirement for informed consent was waived because of the retrospective design and the use of de-identified data.

3. RESULTS

3.1. Patient characteristics

A total of 443 unique patients were analysed: 73 in 2021, 73 in 2022, 109 in 2023, 71 in 2024, and 117 in 2025 (Figure 1). There were 228 male patients (51.5%) and 213 female (48.1%); sex was missing in 2 records (0.5%). Most patients originated from Luanda and adjacent municipalities (n=317; 71.6%); 125 (28.2%) came from other provinces (Figure 2). Health coverage was state-funded in 442 patients (99.8%). The sex distribution was stable across the five years (chi-square p=0.985), and no significant differences between years were found in age at

diagnosis (Kruskal-Wallis $p=0.429$), age at surgery ($p=0.208$), or head circumference ($p=0.817$). Table 1 summarises the cohort characteristics.

Median age at diagnosis was 14 days (IQR 2–122), and median age at surgery, documented in 359 patients, was 32 days (IQR 12–122), corresponding to 1.1 months (IQR 0.4–4.0) (Figure 4). The median interval between diagnosis and surgery was 0 days (IQR 0–23), indicating that most children were operated during the same admission. Median operative time was 40 minutes (mean 45.6; standard deviation 24.4). Head circumference at diagnosis, available in 438 patients, had a median of 50.0 cm (IQR 40–58); among infants diagnosed before 90 days of age the median was 46.0 cm (IQR 38–60) (Figure 7).

Table 1. Demographic and clinical characteristics of the cohort (n=443).

Variable	Category	n (%)
Sex	Male	228 (51.5)
	Female	213 (48.1)
	Missing	2 (0.5)
Province of origin	Luanda and adjacent municipalities	317 (71.6)
	Other provinces	125 (28.2)
	Unknown	1 (0.2)
Health coverage	State-funded	442 (99.8)
Initial procedure	VP shunt	428 (96.6)
	No shunt	9 (2.0)
	Missing/indeterminate	6 (1.4)
Valve documented (n=441)	Shabra	433 (98.2)
Prophylaxis documented (n=442)	Ceftriaxone alone	435 (98.4)
	Vancomycin + ceftriaxone	6 (1.4)
	Ceftriaxone + metronidazole	1 (0.2)
Type of hydrocephalus	Congenital	442 (99.8)
	Communicating	423 (95.5)
	Triventricular	10 (2.3)
	Obstructive	4 (0.9)
	Extraventricular	3 (0.7)
	Intraventricular	2 (0.5)
	Missing	1 (0.2)

Values are n (%). VP, ventriculoperitoneal.

Table 1. (continued) Continuous variables.

Variable	n	Median (IQR)	Mean $\pm$ SD
Age at diagnosis (days)	440	14 (2–122)	69.3 $\pm$ 97.8
Age at surgery (days)	359	32 (12–122)	84.0 $\pm$ 110.3
Diagnosis-to-surgery interval (days)	357	0 (0–23)	14.1 $\pm$ 57.6
Operative time (minutes)	418	40 (30–58)	45.6 $\pm$ 24.4
Head circumference at diagnosis (cm)	438	50.0 (40–58)	50.5 $\pm$ 11.7

IQR, interquartile range; SD, standard deviation.

3.2. Aetiology, type of hydrocephalus, and comorbidities

Hydrocephalus was congenital in 442 patients (99.8%) and communicating in 423 (95.5%); there were 10 triventricular cases (2.3%), 4 obstructive (0.9%), 3 extraventricular (0.7%), and 2 intraventricular (0.5%). The most frequent comorbidities were myelomeningocele in 88 patients (19.9%; 95% CI 16.4–23.8), clubfoot in 33 (7.4%), and meningitis in 31 (7.0%); ventriculitis and sepsis were recorded in 5 (1.1%) and 4 (0.9%), respectively (Figure 3). No comorbidity was recorded in 310 patients (70.0%).

3.3. Procedure and prophylaxis

The initial procedure was recorded as VP shunt in 428 patients (96.6%); in 9 (2.0%) no shunt was inserted and in 6 (1.4%) the record was missing or indeterminate. The valve was documented in 441 patients, of whom 433 (98.2%) received the Shabra model. Antibiotic prophylaxis was documented in 442 patients: ceftriaxone alone in 435 (98.4% of those documented), vancomycin with ceftriaxone in 6 (1.4%), and ceftriaxone with metronidazole in 1 (0.2%). Initial imaging combined transfontanellar ultrasound and computed tomography (CT) in 232 patients (52.6% of the 441 with imaging recorded); ultrasound alone was used in 206 (46.7%).

3.4. Complications and revisions

Early complications (<30 days) were recorded in 110 patients (24.8%; 95% CI 21.1–29.0). After categorisation, the most frequent were meningitis (n=24; 21.8% of recorded complications) and catheter infection (n=22; 20.0%), followed by malaria (n=9; 8.2%), catheter obstruction (n=7; 6.4%), catheter extrusion or migration (n=6; 5.5%), catheter dysfunction (n=4; 3.6%), sepsis (n=4; 3.6%), and ventriculitis (n=1; 0.9%); the remaining entities were grouped as “other” (n=33; 30.0%) (Table 2, Figure 5). One late complication (>30 days) was recorded, a catheter infection. Shunt revision was performed in 3 patients (0.7%; 95% CI 0.2–2.0), at 21 days, 22 days, and 9 months after surgery.

Table 2. Categorised early complications (<30 days) (n=110 patients with a recorded complication).

Complication	n	% of complications	% of cohort (n=443)
Meningitis	24	21.8	5.4
Catheter infection	22	20.0	5.0
Malaria	9	8.2	2.0
Catheter obstruction	7	6.4	1.6
Catheter extrusion/migration	6	5.5	1.4
Catheter dysfunction	4	3.6	0.9
Sepsis	4	3.6	0.9
Ventriculitis	1	0.9	0.2
Other	33	30.0	7.4

One late complication (>30 days) was recorded (catheter infection). Shunt revision was performed in 3 patients (0.7%; 95% CI 0.2–2.0).

3.5. Mortality and follow-up

Hospital mortality was 8.8% (n=39; 95% CI 6.5–11.8) and 30-day mortality 0.2% (n=1); overall mortality (hospital or 30-day) was 9.0% (n=40; 95% CI 6.7–12.1) (Figure 6). Follow-up duration, documented in 269 patients, had a median of 27 days (IQR 18–39; maximum 105 days). Loss to follow-up was recorded in 57 patients (12.9%).

3.6. Inferential analysis

The presence of a complication or revision was associated with younger age at diagnosis (median 5 days, IQR 1–53, vs 22 days, IQR 3–188; $p=0.010$) and younger age at surgery (24 days, IQR 10–72, vs 58 days, IQR 15–192; $p=0.021$). No differences were found for sex (Fisher $p=0.192$), head circumference ($p=0.594$), or operative time ($p=0.385$). Myelomeningocele was associated with complication or revision in univariable analysis (31/88 [35.2%] vs 83/355 [23.4%]; OR 1.78; 95% CI 1.08–2.94; $p=0.029$), an association that attenuated after adjustment for sex and age (OR 1.60; 95% CI 0.94–2.74; $p=0.085$). No associations were found between sex and death ($p=0.411$), province and death ($p=0.855$), or province and complications ($p=0.630$); meningitis recorded as a comorbidity was not associated with death ($p=0.509$), and mortality did not differ by age at diagnosis ($p=0.745$), age at surgery ($p=0.923$), or head circumference ($p=0.193$). Table 3 summarises the bivariate analyses.

Table 3. Bivariate analyses: factors associated with complication or revision and with mortality.

Comparison	Group 1 vs group 2	Measure of association (95% CI)	p
Age at diagnosis × complication/revision	5 vs 22 days (medians)	Mann-Whitney U	0.010
Age at surgery × complication/revision	24 vs 58 days (medians)	Mann-Whitney U	0.021
Myelomeningocele × complication/revision	35.2% vs 23.4%	OR 1.78 (1.08–2.94)	0.029
Myelomeningocele × complication/revision (adjusted)	—	OR 1.60 (0.94–2.74)	0.085
Sex × complication/revision	—	Fisher's exact test	0.192
Sex × death	—	Fisher's exact test	0.411
Province × death	—	Fisher's exact test	0.855
Province × complication/revision	—	Fisher's exact test	0.630
Meningitis × death	—	Fisher's exact test	0.509
Sex × year	—	Chi-square	0.985

OR, odds ratio; CI, confidence interval. Logistic regression was adjusted for sex, age at diagnosis, and age at surgery. Continuous variables were compared with the Mann-Whitney U test.

4. DISCUSSION

In this cohort of 443 children operated for hydrocephalus at a tertiary hospital in Luanda, hospital mortality was 8.8% and about one quarter of patients had early complications, predominantly meningitis and catheter infection. Shunt revisions were rare (0.7%), a figure that should be read against a median follow-up of only 27 days.

The observed mortality lies within the range reported in Africa, although near the lower end of some regional series. In the Kijabe series in Kenya, mortality was 7.1% with 65% of shunts functioning at 2 years²⁴. Cohorts from Zambia and Malawi described late presentation, early postoperative complications, and early mortality^{9,25}. In high-income settings, early mortality after VP shunting is generally lower, but shunt failure rates in the first year remain high, between 30% and 40%^{14,15}.

The predominance of communicating congenital hydrocephalus associated with myelomeningocele (19.9%) distinguishes this series from East African cohorts, in which postinfectious hydrocephalus is the most common cause^{7,8,26}. Neural tube defects remain a major cause of paediatric hydrocephalus in Africa, where the prevalence of myelomeningocele is higher than in other regions and mandatory folic-acid fortification of flour is not yet widespread^{10,11,12,13,27,28}. The association between myelomeningocele and complications, significant in univariable analysis and attenuated after adjustment, is consistent with the higher risk of infection and shunt dysfunction described in these children^{27,28}.

The higher frequency of complications in younger patients at diagnosis and at surgery may reflect the severity of hydrocephalus requiring early neonatal intervention, the immunological vulnerability of infants, or the technical difficulty of surgery at this age. As this is an observational study, these are hypotheses. Catheter infection and meningitis together accounted for more than four in ten recorded early complications, underlining the role of perioperative prevention: standardised protocols reduced shunt infection in multicentre high-income networks^{16,17,18}, and their adaptation to African centers is feasible and recommended^{18,29}.

The absence of published series from Angola limits local comparison. The almost universal state coverage, surgery mostly in the same admission as diagnosis, and systematic documentation of

prophylaxis are favourable aspects. Conversely, exclusive reliance on VP shunting and the absence of an endoscopic programme, which has been assessed favourably in African children^{19,20,21,22,23}, restrict therapeutic alternatives. Strengthening the paediatric neurosurgery workforce and systematic case registration have been identified as continental priorities^{5,6} and apply directly to Angola. In a different clinical context, Dostovic and colleagues applied the same retrospective registration of complications and outcomes after VP shunting in adults³⁰, illustrating the relevance of this approach in general neurosurgery.

These results cannot be generalised to the whole country, given the centralisation of treatment in Luanda and the retrospective nature of data collection. Comparison with international series should consider differences in aetiology, age at surgery, and criteria for recording complications.

5. LIMITATIONS

The retrospective design and incomplete completion of records limited data availability: age at surgery was documented in only 359 patients and follow-up in 269. The short follow-up (median 27 days) underestimates late complications and revisions and precludes reliable estimates of long-term survival; loss to follow-up recorded in 57 patients (12.9%) contributes to the same bias. Head circumference values were heterogeneous, some implausible, and should be interpreted with caution. Data on neurodevelopmental outcome and on specific causes of death were not collected. Finally, the number of deaths (n=40) limited the statistical power of adjusted analyses.

6. CONCLUSION

In this Angolan series, hospital mortality after VP shunt insertion was 8.8% and early complications occurred in about one quarter of children, predominantly meningitis and catheter infection. Complications were more frequent in infants operated earlier and in patients with myelomeningocele. The true scale of revisions and long-term survival can only be estimated with structured follow-up; a national hydrocephalus registry in Angola would allow these outcomes to be monitored.

DECLARATIONS

Ethics approval and consent to participate

This study involved a retrospective analysis of de-identified institutional clinical records and was approved by the Ethics Committee of Hospital Pediátrico David Bernardino (reference no. HP-DP 95/2026). The requirement for informed consent to participate was waived by the Ethics Committee of Hospital Pediátrico David Bernardino because of the retrospective nature of the study and the use of de-identified data. The study was conducted in accordance with the ethical principles of the Declaration of Helsinki, applicable Angolan bioethics legislation and regulations, and the Angolan Personal Data Protection Law (Law No. 22/11 of 17 June). Appropriate measures were implemented to safeguard participants' rights, privacy, confidentiality, and personal data throughout the study.

Clinical trial number

Not applicable.

Consent for publication

Not applicable.

Availability of data and materials

The datasets generated and/or analysed during the current study are derived from institutional clinical records and are not publicly available because of patient confidentiality and institutional data-protection requirements. De-identified data may be made available from the corresponding author upon reasonable request and subject to approval by Hospital Pediátrico David Bernardino.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

Sérgio Neto conceived and designed the study, developed the study protocol, supervised data collection, curated and verified the dataset, performed the statistical analyses, interpreted the findings, and drafted the original manuscript. Moisés Cinco Reis Jessé contributed to data acquisition and validation, interpretation of the findings, and critical revision of the manuscript for important intellectual content. All authors reviewed and approved the final manuscript and agree to be accountable for all aspects of the work.

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FIGURES

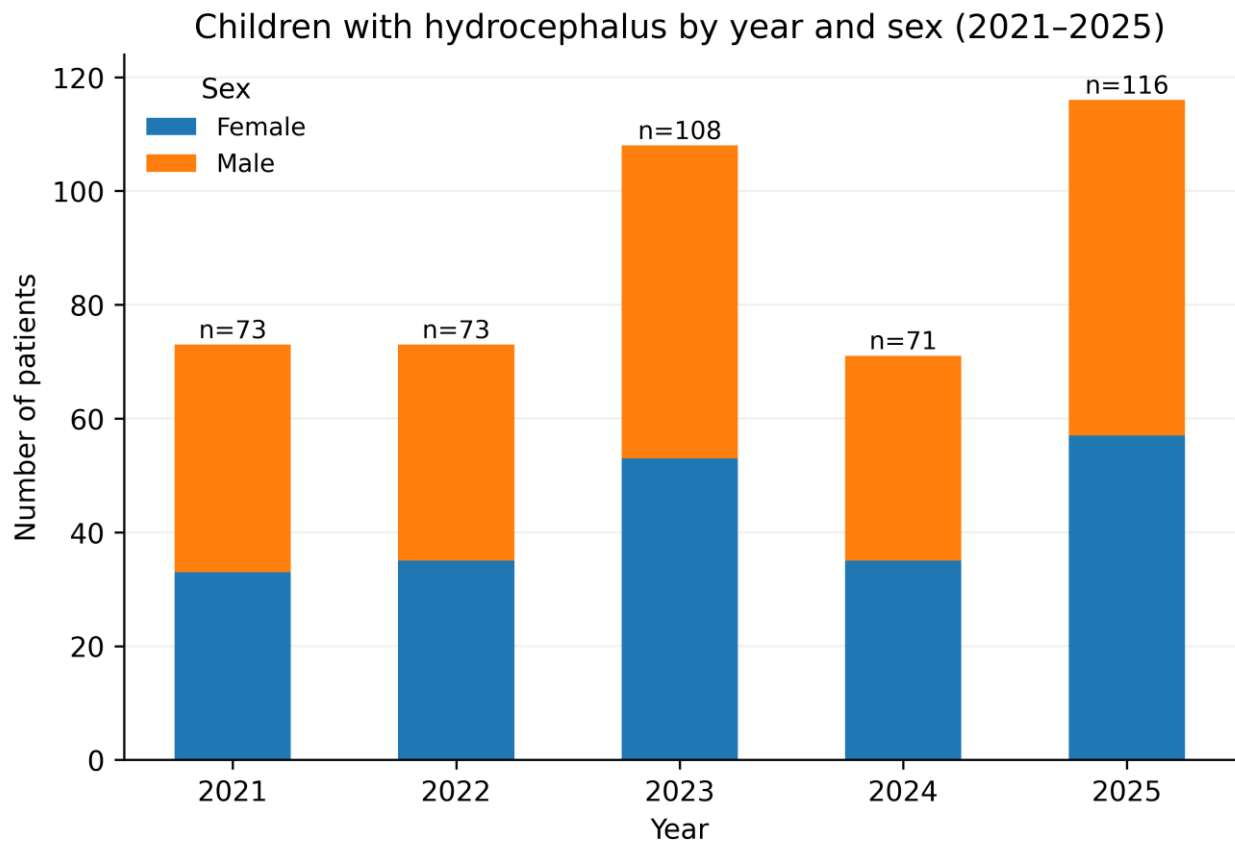


Figure 1. Annual distribution of the cohort by sex (2021–2025).

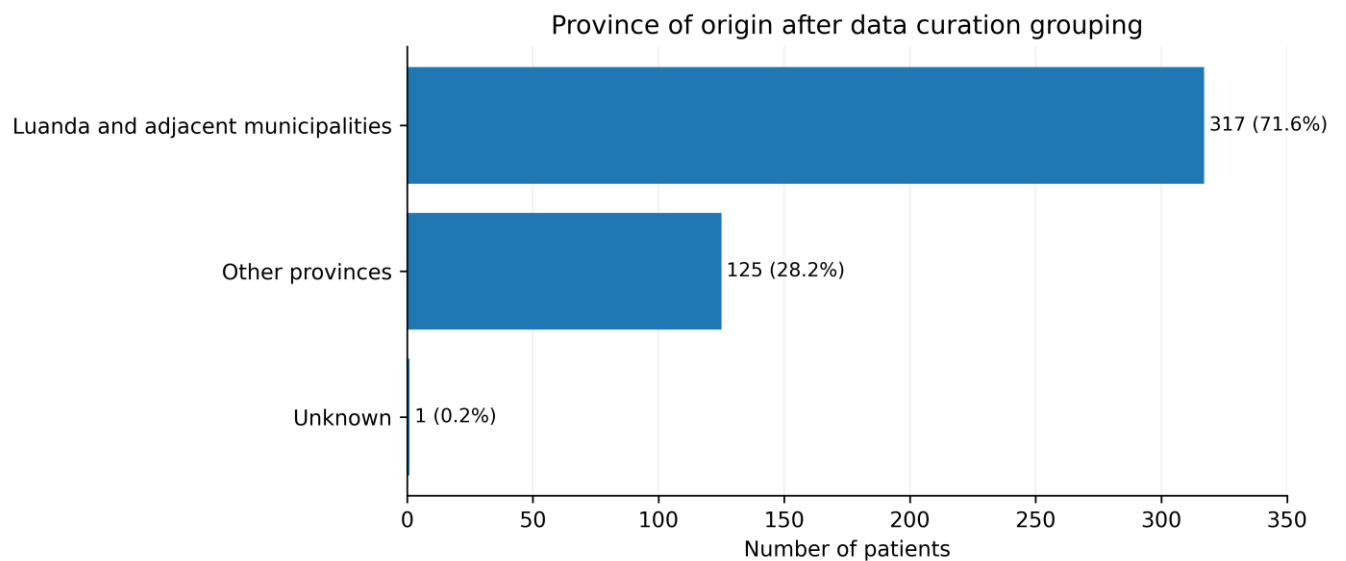


Figure 2. Province of origin after grouping (“Luanda and adjacent municipalities” vs other provinces).

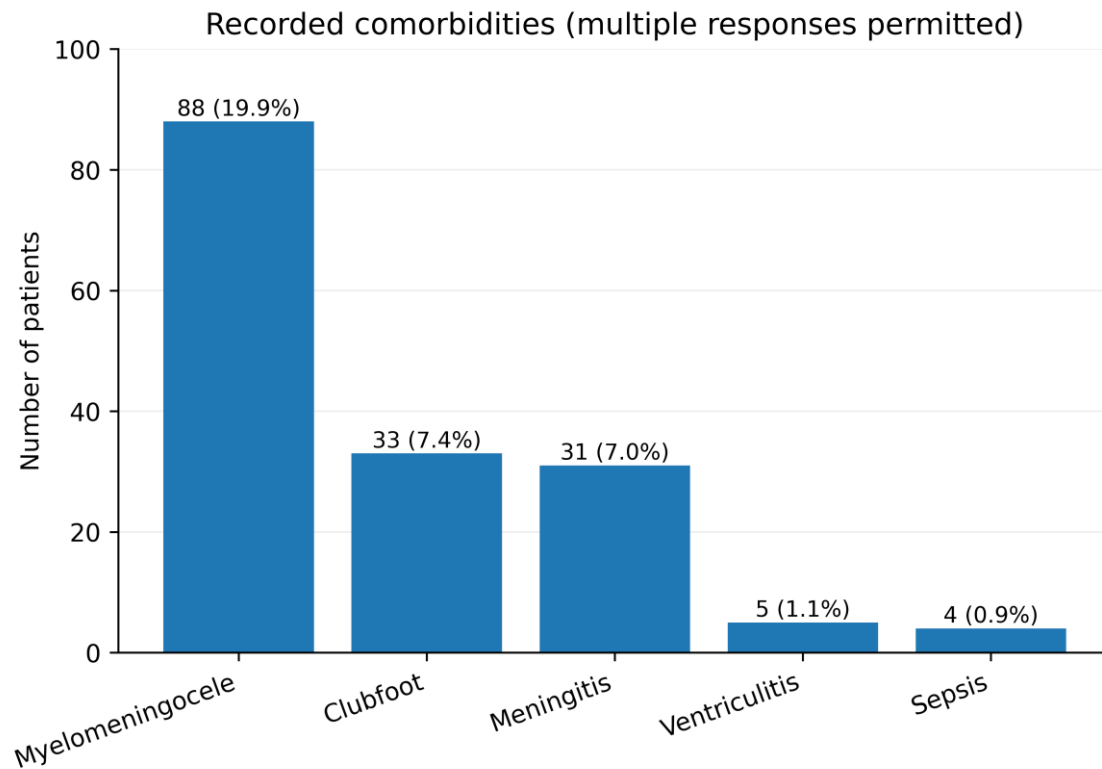


Figure 3. Recorded comorbidities (percentages of the total cohort).

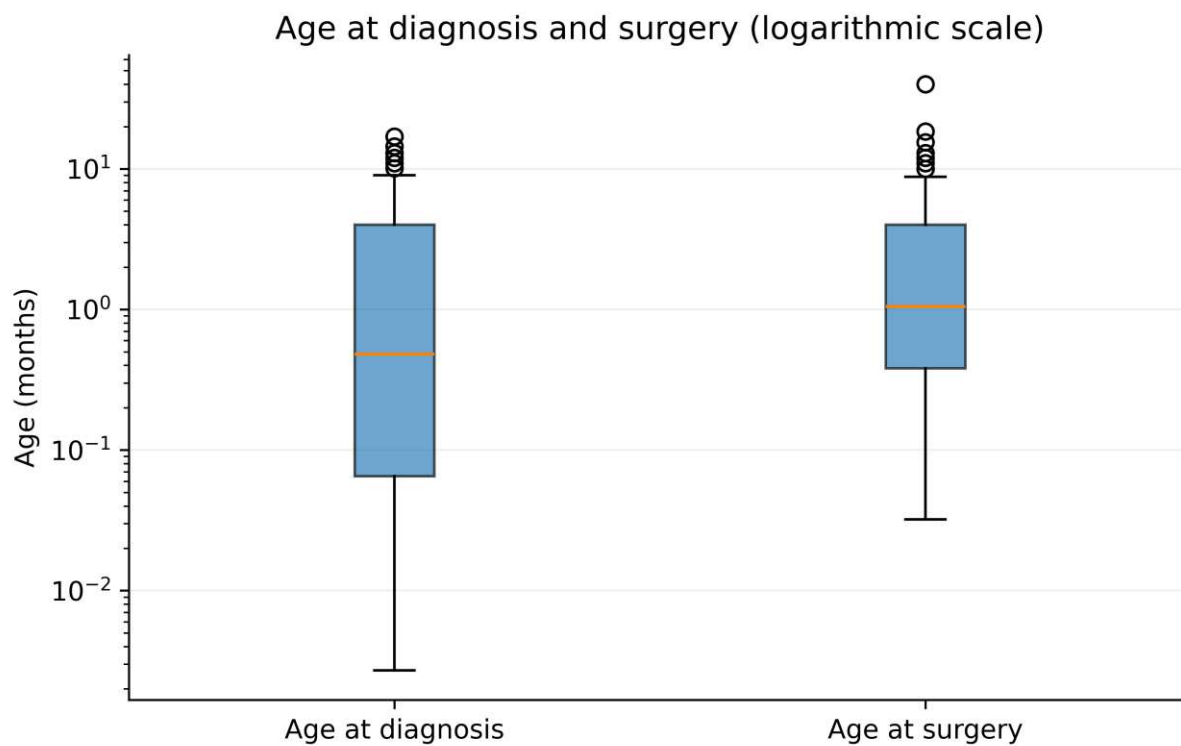


Figure 4. Age at diagnosis and at surgery, in months (logarithmic scale).

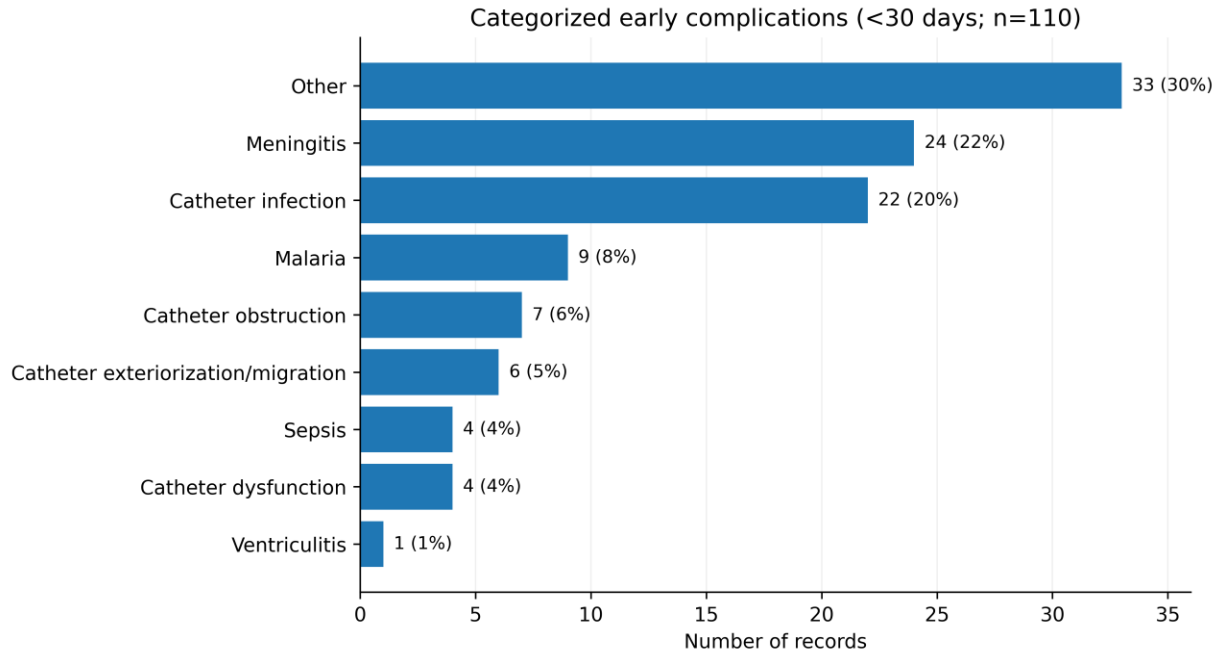


Figure 5. Categorized early complications (<30 days) (n=110 records).

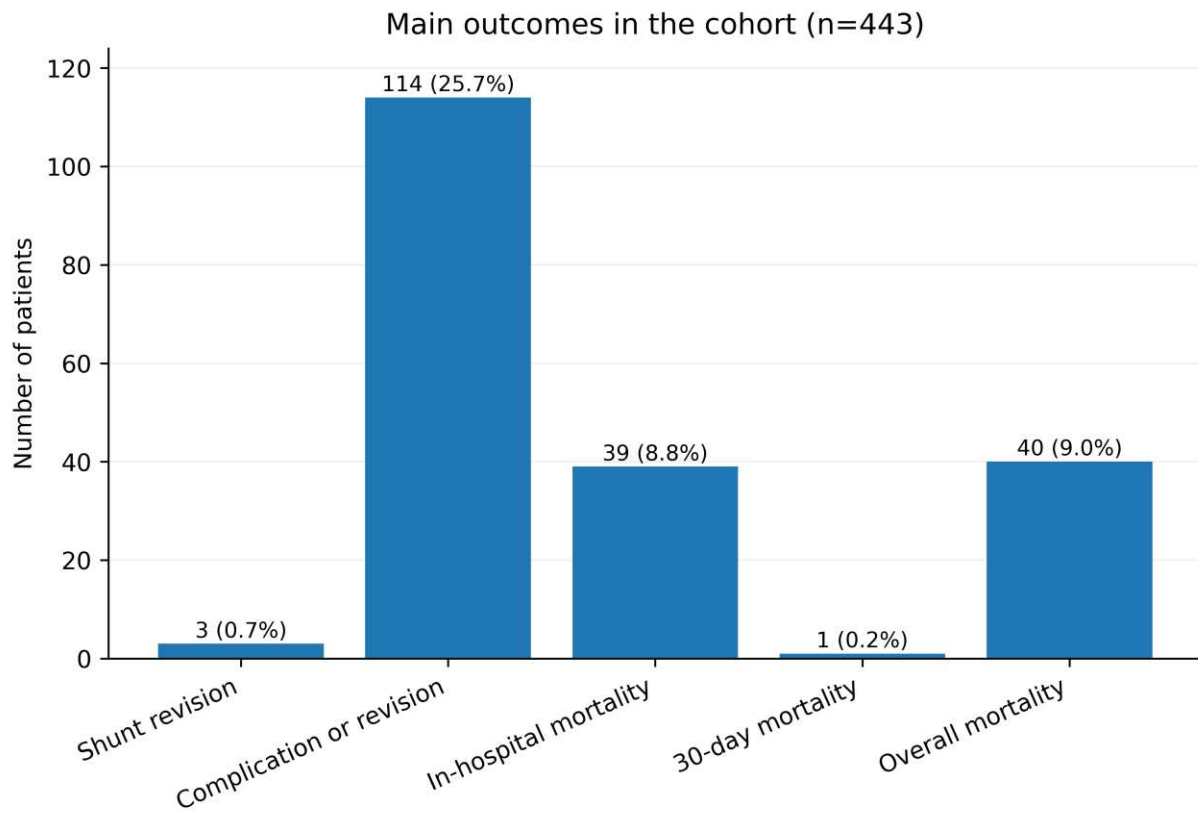


Figure 6. Main outcomes in the cohort: shunt revision, complication or revision, hospital mortality, 30-day mortality, and overall mortality.

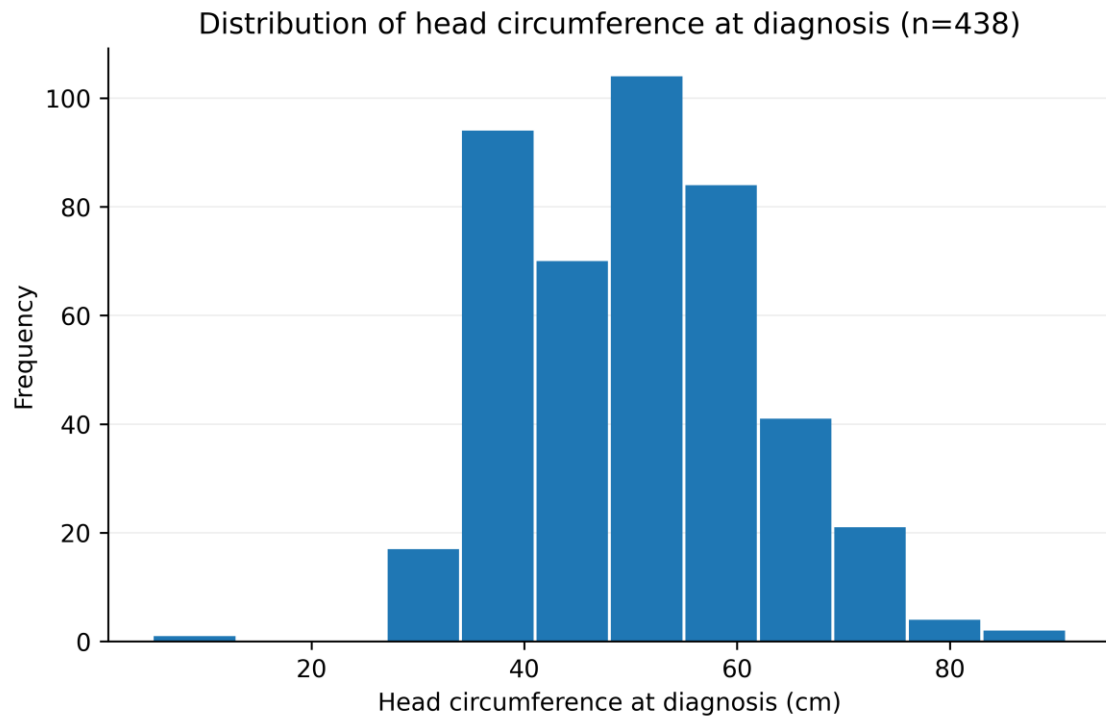


Figure 7. Distribution of head circumference at diagnosis (n=438).