Original Research Article

The Role of Interventional Radiology in Patients Management During Sudan War 2023-2024: A Western Sudan Experience

Abstract

Background: The purpose of this study is to evaluate the availability of interventional radiology services in Western Sudan from 2023 to 2024, during the Sudan War. This study aimed to evaluate the role of interventional radiology in the country's ongoing conflict**. Methodology:** This is a retrospective descriptive study with a prospective component that was conducted at El-Obeid International Hospital in North Kordofan State, Sudan, in August and September 2024. All information on patients who had interventional radiology operations between August 15th, 2023 and August 15th, 2024 was obtained from the hospital**. Results:** The findings revealed that 41% of the 131 patients received operations in the Interventional Radiology Clinic and 59% in the Catheterization Laboratory department. Among the 131 patients, 55% were men and 45% were women. The most common age group for undergoing IR treatments was 46-65 years, followed by ≥65 and 18-45 years, with incidence rates of 40%, 34%, and 25%, respectively. 41% of the procedures were performed in the interventional radiology clinic, with 59% performed in the catheterization laboratory. The most common technique was permacath implantation (36%). **Conclusion:** The ongoing conflict between 2023 and 2024 aggravated the situation. As a result, our study discovered that the only IR facility in Western Sudan during this difficult time is based in El-Obeid and serves seven states. This was exemplified by a severe breakdown in the healthcare system, the loss of basic needs, great poverty, and the plight of the refugees.

Keywords: interventional radiology, catheterization laboratory, interventional radiology theater, interventional radiology clinic, Sudan.

Introduction

As is commonly known, interventional radiology is expanding rapidly, offering more options to open surgery. It offers speedier healing and a better patient experience with minimally invasive imaging-guided treatment [1]. Healthcare relies on interventional radiology for disease diagnosis, treatment planning, and response assessment [2]. Interventional radiologists address several clinical problems and perform more treatments each year. Trained allied health providers can perform certain basic interventional radiology treatments. Interventional radiology units vary in size based on hospital size, services, and proximity to adjacent units. Emergency interventional radiology should be available to all patients [3].

However, interventional radiology services are scarce in many distant areas. These areas have insufficient radiology and medical imaging infrastructure and staff constraints that affect interventional image-guided operations. Workload, poor imaging and interventional equipment, and limited training exposure have hindered remote interventional radiologists' recruitment and retention. Additionally, attempts to improve radiology services in remote locations address the staff deficit and the lack of needed equipment and other resources [2].

Interventional radiology clinics should evaluate all patients referred for procedures. The

IR clinic may only accept referrals for complicated treatments like lower limb angioplasty and uterine artery embolization due to a local personnel shortage. IRs should try to open a pre-procedure evaluation clinic in their hospitals [3].
Interventional radiology clinics are crucial to clinical IR service establishment. The goal of an IR clinic is to understand the patient's needs and allow them to ask inquiries. The clinic engagement will improve doctor-patient connections and patient treatment. If possible, the clinic consultation should be in a private room with a radiological nurse. Virtual clinics are well-known [4] and can be simply applied to IR practice. The clinic discussion should cover medical history, symptoms, risk factors (allergies, bleeding disorders, anticoagulation, renal impairment), and physical examinations. Clinic consultations are useful for discussing therapy logistics and consent.
As interventional radiology plays a large role in patient management, it is one of the biggest hurdles in low-resource settings because it is expensive and requires data availability for suitable interventions. Sudan's interventional radiology program is growing, although catheter laboratory data is scarce. This study examined interventional radiology's involvement in patient care during Sudan War 2023-2024.

Materials and methods

This is a descriptive study that is retrospective in nature, but it also has a prospective component. The research was carried out at El-Obeid International Hospital (Elda man), which is situated in North Kordofan State, Sudan. The hospital is home to both a catheterization laboratory and an interventional radiology clinic. The investigation was held beginning in August 2023 and continuing until September 2024. All of the data that was accessible from the catheter laboratory and interventional radiology clinic between the dates of August 15, 2023 and September 15, 2024 was included in the sample in its entirety. All of the metrics that were accessible within the report and file of each individual patient were included in the data that was pulled. All patient’s safety measures were undertaken in accordance with clinical practice and guidelines provided by British Society of interventional Radiology [5].

Results

The study included 131 patients aged one year to 85 years who received interventional radiology treatments. The mean age and standard deviation were 54.5±17.5.
The majority of the study participants were between the ages of 46 and 65, followed by > 65 and 18 to 45 years, with 52/131 (40%), 44/131 (34%), and 33/131 (25%).
In terms of education, the majority of participants (40%) received basic education, followed by secondary education (26%), university (21%), illiteracy (13%), and students (6%).
The majority of the patients were unemployed (40%), with other jobs accounting for 28%, 20% farmers, 6% teachers, and 6% students. Table (1a) and Figure (1a).
In terms of marital status, 75% of the patients were married, 14% were widows, and 11% were students, as shown in Figure 1b.
In terms of residency, the majority (93%) resided in cities, while % lived in rural areas,

as shown in Table 1b.
In terms of monthly income, 57% earned less than $100 per month, 42% made between 101 and $500, and 1% earned more than $1,000 per month, as seen in the figure.
Table (2) reveals that the greatest procedure cost was between 101 and 500 USD (52%), 40% less than 50 USD, 2% between 50 and 100 USD, and 1% greater than 1000 USD.
The majority of patients (56%) required no vascular access, followed by internal jugular vein access in 37%, common femoral artery access in 7%, and common femoral vein access in 2%. As shown in Table 2.
Figure 3 shows that the most frequently done procedure was Permacath insertion (36%), followed by image-guided biopsy (28%), external biliary drainage (9%), image-guided drainage (6%), antegrade stenting (3%), PAIR (2%), angioplasty (2%), tumor embolization (2%), transarterial chemoembolization (2%), alcohol ablation (1%), varicocele coiling (1%), prostatic artery embolization (1%), cholecystostomy (1%), nephrostomy (1%), renal cyst aspiration (1%), and bleomycin injection.
Figure 4 shows that the majority of patients (78%) come from North Kordofan state, followed by West Kordofan (8%), East Darfur (5%), White Nile (3%), South Kordofan (2%), North Darfur (2%), and South Darfur (2%).
Concerning the diagnosis. The most common diagnosis was ESRD (37%), followed by liver metastases (4%), pancreatic carcinoma (4%), bronchial carcinoma (4%), cholangiocarcinoma (4%), lymphoma (3%), bladder tumor (2%), empyema (2%), and limb ischemia (2%).
Abdominal lymphoma, biloma, BPH, cervical carcinoma, Hydatid cyst, intrahepatic cholangiocarcinoma, liver cyst, and metastatic GIST. Each measure (1%): paraspinal mass, pelvic abscess, pelvic cyst, pelvic liposarcoma, plasmacytoma, PUJ obstruction, renal cyst, retroperitoneal sarcoma, small bowel mass, suprarenal mass, testicular carcinoma, thymoma uterine carcinoma, varicocele, vesicovaginal fistula, obstructed kidney, and ovarian carcinoma; Table 5, Figure (5).

Table 1a. Distribution of the study population by sex and demographic characteristics.

Variable	Females	Males	Total
Age (yrs.)			
<18	0	2	2
18 -45	14	19	33
46 - 65.	22	30	52
>65 yrs.	23	21	44
Total	59	72	131
Education			
Illiterate	10	7	17
Basic	27	26	53
Secondary	13	21	34

University	9	18	27
Total	59	72	131
Occupation			
Student	2	6	8
Teacher	4	4	8
Farmer	7	18	25
Jobless	41	12	53
Others	5	32	37
Total	59	72	131

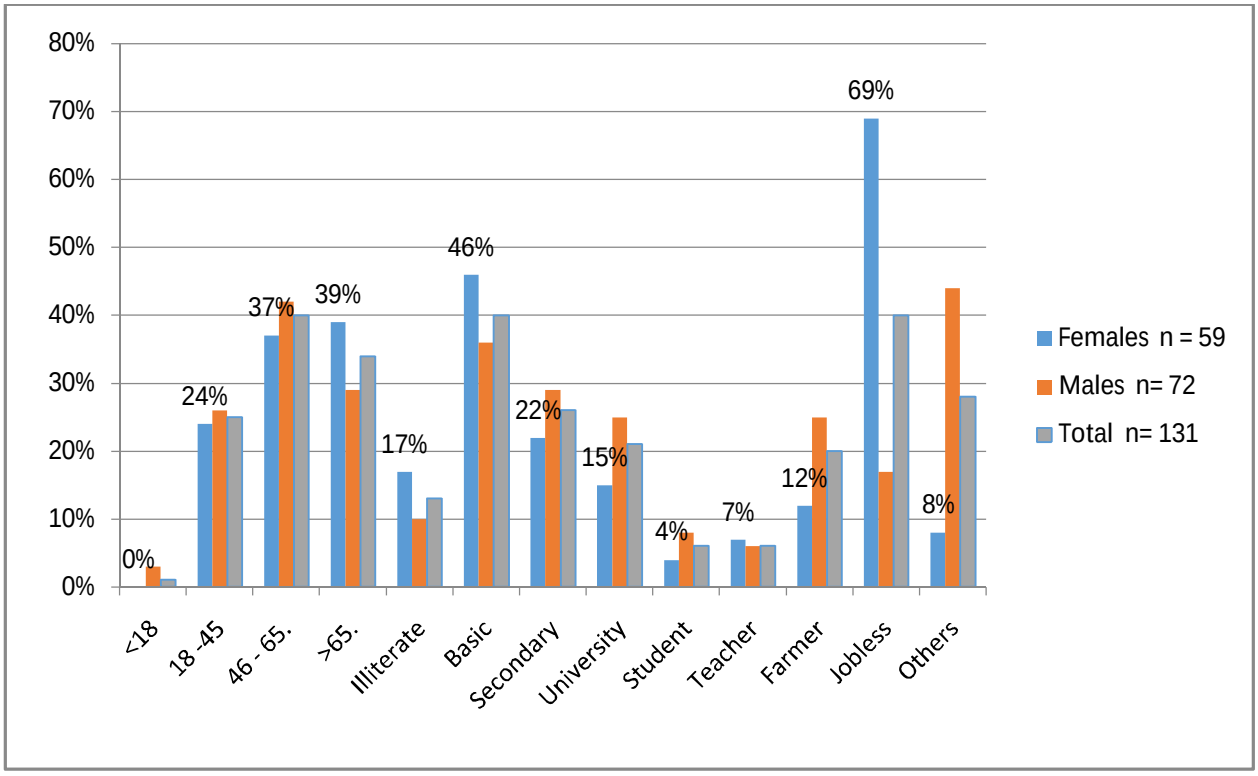

Figure 1a. Description of the study population by sex and demographic characteristics.

Table 1b. Distribution of the study population by sex and demographic characteristics.

Variable	Females	Males	Total
Marital status			
Single	2	12	14
Married	38	60	98

Widow	19	0	19
Total	59	72	131
Residence			
Urban	53	69	122
Rural	6	3	9
Total	59	72	131
Income (USD/ month)			
<100	37	38	75
100 - 500	22	33	55
501-1000	0	1	1
Total	59	72	131

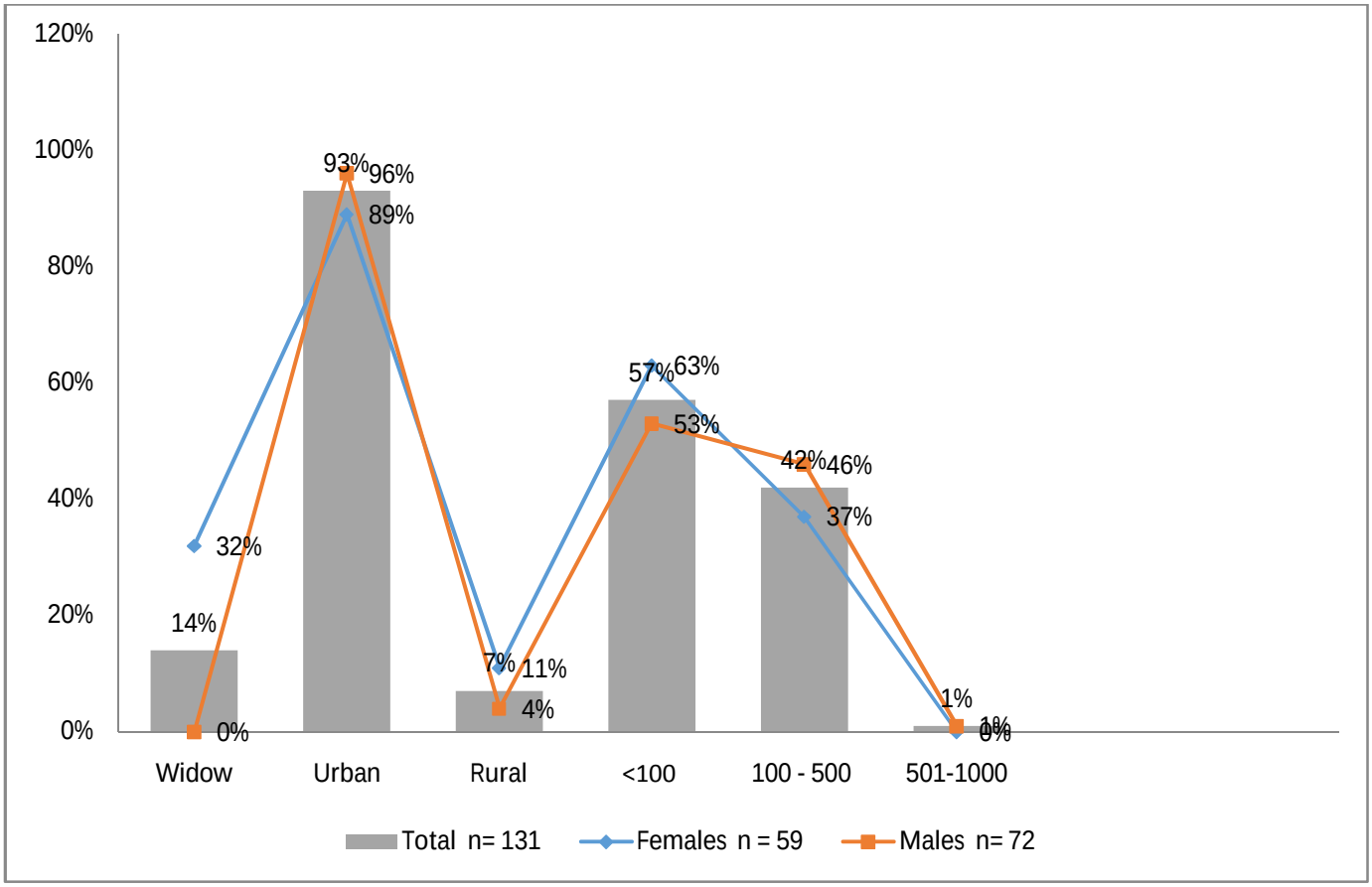

Figure 1b. Description of the study population by sex and demographic characteristics.

Table 2. Distribution of the study population by the operating room and the procedure cost and vascular access.

Variable	Interventional Radiology clinic	Cath lab	Total
Procedure cost (USD)			
50	53	0	53
50 - 100	1	1	2
101 to 500	0	68	68
501 to 1000	0	1	1
>1000	0	7	7
Total	54	77	131
Vascular access			
None	54	20	74
Common femoral artery	0	7	7
Internal jugular vein	0	48	48
Common femoral vein	0	2	2
Total	54	77	131

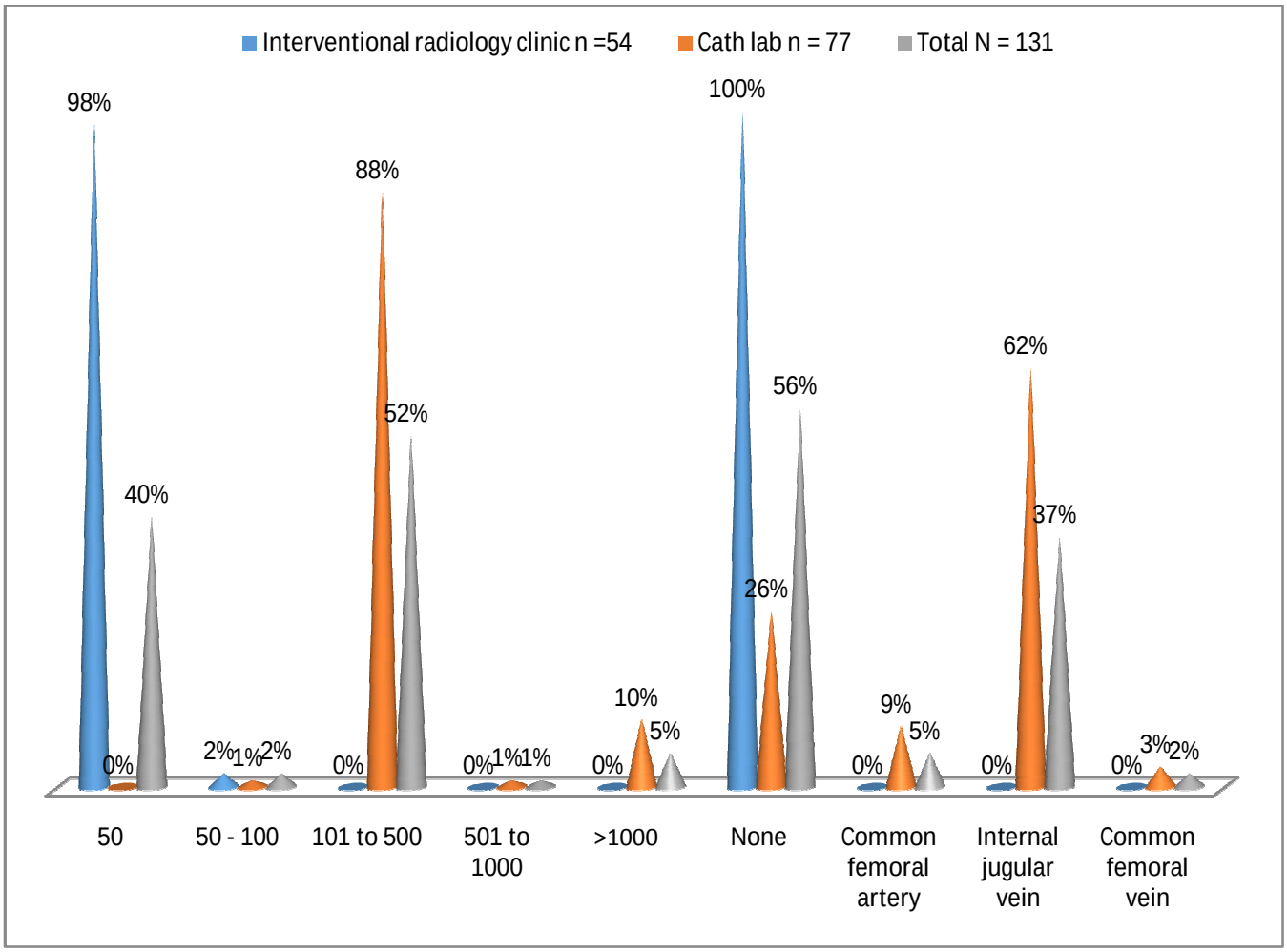

Figure 2. Description of the study population by the operating room and the procedure cost and vascular access.

Table 3. Distribution of the study population by operating room and the type of procedure.

Variable	Interventional radiology clinic	Cath lab	Total
Type of procedure			
Permacath	0	50	50
External biliary drainage	0	13	13
Image guided biopsy	38	0	38
Image guided drainage	9	0	9
PAIR	2	0	2
Angioplasty	0	2	2
Antegrade stenting	0	4	4
Transarterial chemoembolization	0	2	2

Tumor embolization	0	2	2
Alcohol ablation	1	0	1
Varicocele coiling	0	1	1
Prostatic artery embolization	0	1	1
Cholecystostomy	0	1	1
Nephrostomy	3	0	3
Renal cyst aspiration	1	0	1
Bleomycin injection	0	1	1
Total	54	77	131

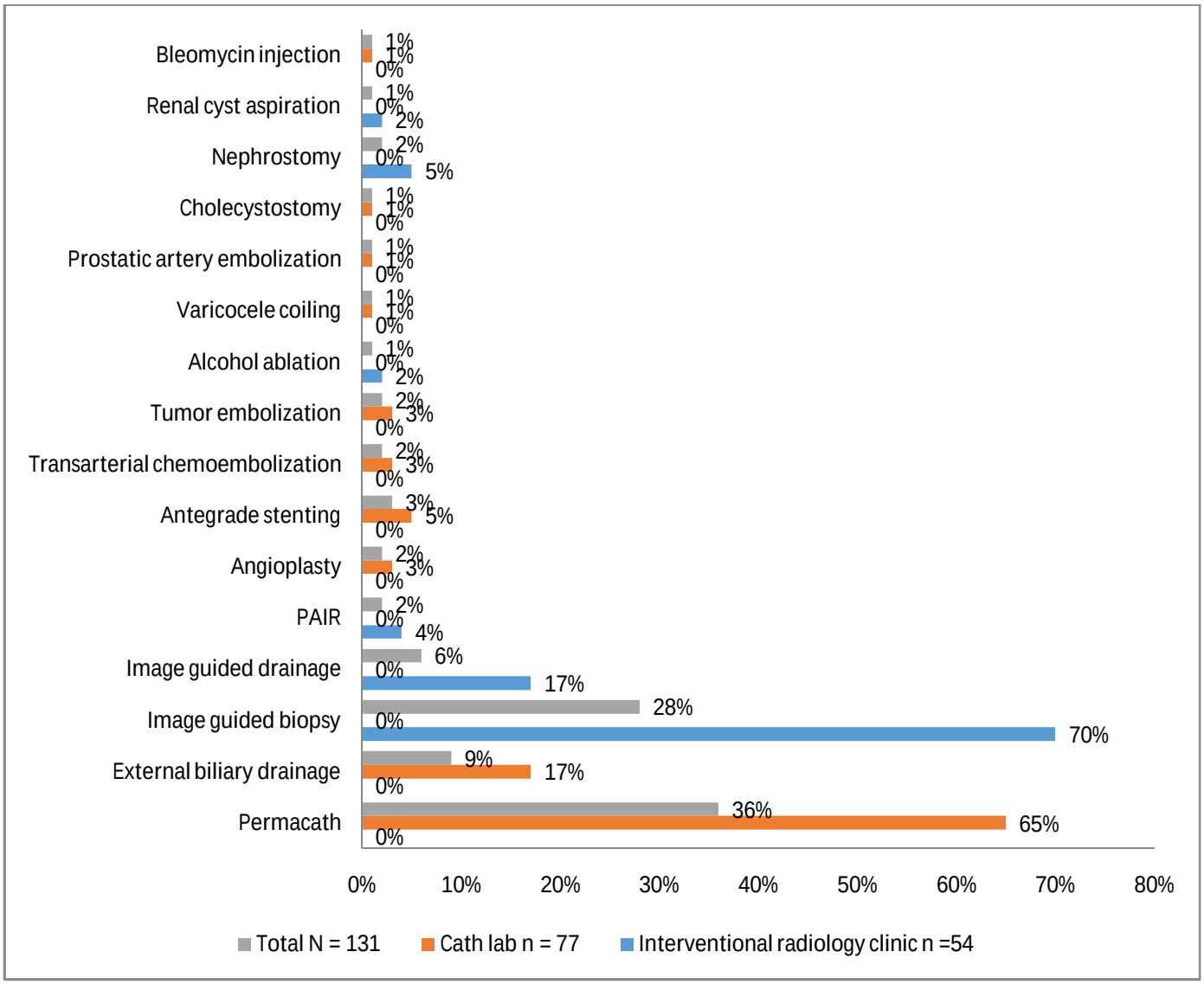

Figure 3. Description of the study population by operating room and the type of procedure.

Table 4. Distribution of the study population by sex and the exact residence of patients.

Variable	Females	Males	Total
Exact residence			
North Kordofan	45	57	102
South Kordofan	1	2	3
West Kordofan	6	3	9
East Darfur	4	3	7
North Darfur	1	2	3
South Darfur	1	2	3
White Nile	1	3	4

Total	59	72	131

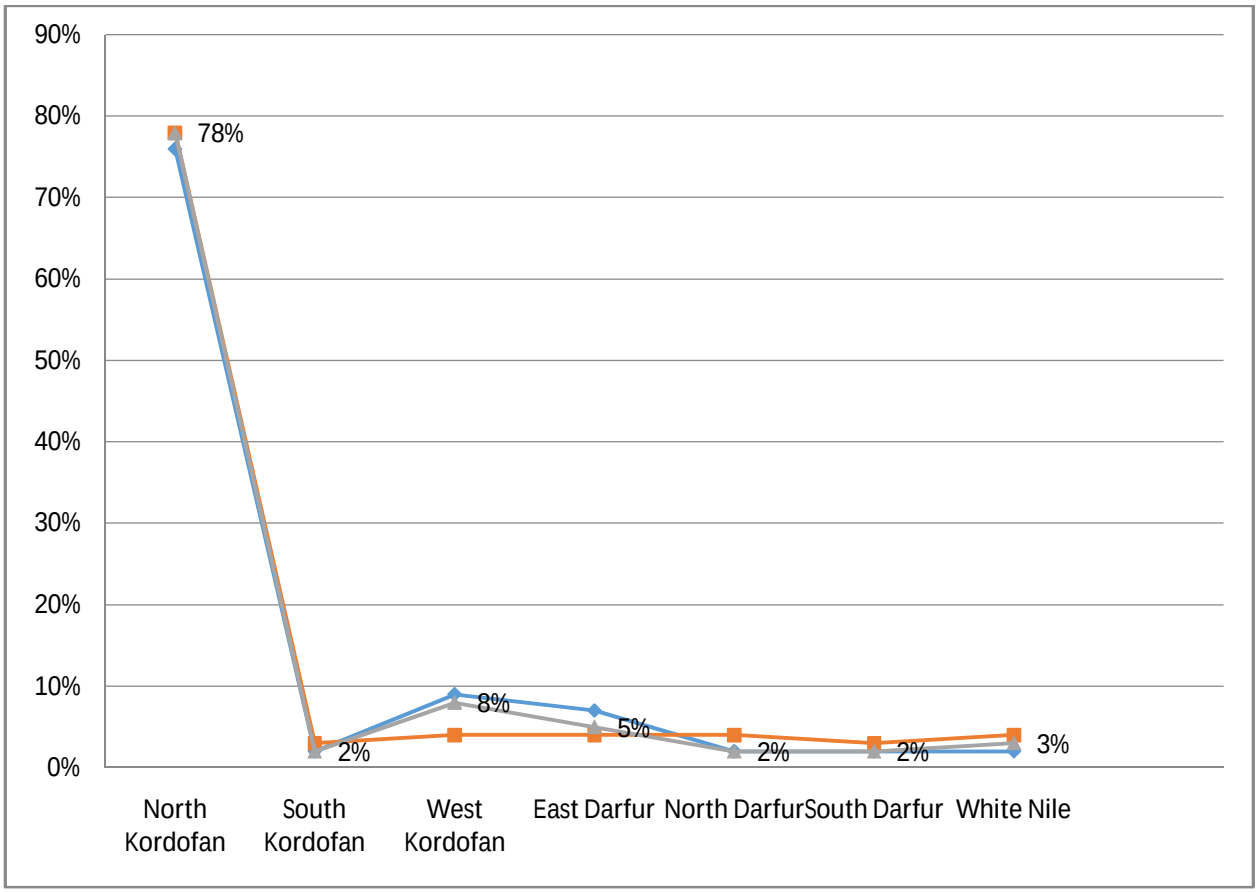

Figure 4. Description of the study population by sex and the exact residence of patients

Table 5. Distribution of the study population by sex and the disease diagnosis.

Variable	Females	Males	Total
Diagnosis			
Abdominal lymphoma	0	1	1
Biloma	1	0	1
Bladder tumor	1	2	3
Bowel Lymphoma	0	1	1
BPH	0	1	1
Bronchial carcinoma	4	4	8
Cervical carcinoma	1	0	1
Cholangiocarcinoma	5	3	8
Cystic hygroma	0	1	1

Empyema	1	1	2
ESRD	19	31	50
Gastric carcinoma	2	0	2
Hepatocellular carcinoma	2	2	4
Hydatid cyst	0	1	1
intrahepatic Cholangiocarcinoma	0	1	1
Limb ischemia	1	1	2
Liver abscess	2	2	4
Liver cyst	0	1	1
Liver metastasis	3	3	6
Lymphoma	3	2	5
Metastatic GIST	1	0	1
Multifocal hepatocellular carcinoma	1	0	1
Obstructed kidney	0	1	1
Ovarian carcinoma	1	0	1
Pancreatic carcinoma	5	2	7
Paraspinal mass	0	1	1
Pelvic abscess	0	1	1
Pelvic cyst	0	1	1
Pelvic liposarcoma	0	1	1
Perinephric abscess	0	2	2
Plasmacytoma	1	0	1
PUJ obstruction	1	0	1
Renal cyst	0	1	1
Retroperitoneal sarcoma	0	1	1
Small bowel mass	0	1	1
Suprarenal mass	1	0	1
Testicular carcinoma	0	1	1
Thymoma	1	0	1
Uterine carcinoma	1	0	1
Varicocele	0	1	1
Vesicovaginal fistula	1	0	1
Total	59	72	131

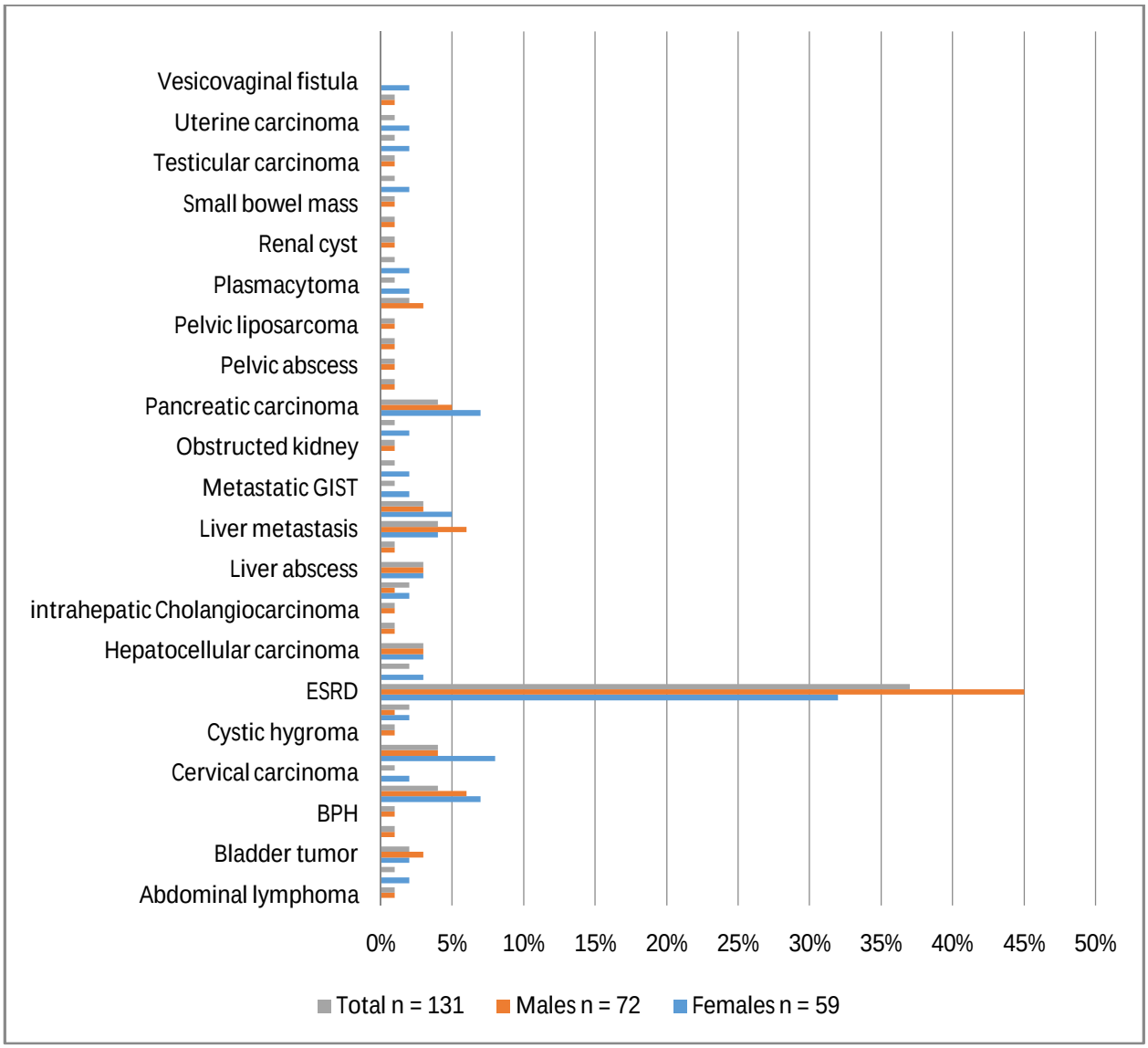

Figure 5. Description of the study population by sex and the diagnosis of the disease.

Discussion:

The current study's findings revealed that there is just one IR facility and catheterization laboratory in El-Obeid International Hospital, which serves seven states. The study population had an average age of 54±17.5. Notably, 1% of the study's patients were under the age of 18.

Interventional radiology is a specialty that treats patients with minimally invasive percutaneous treatments guided by imaging. Interventional radiology procedures are conducted in all hospitals around the world by radiologists who have been educated in these techniques. The Sudan Medical Council recognizes interventional radiology as a specialization of radiology. The majority of interventional radiology operations are

therapeutic in nature, and interventional radiology has the ability to impact all body systems [6]. The current study's findings revealed that permacath insertion was the most frequently performed procedure among patients referred to El-Obeid International Hospital. The main reason for this was that the dialysis catheter was subsidized by a charity organization that supports patients with renal failure, and the procedure fees were significantly discounted by the hospital administration to reduce the cost burden on the patients' relatives. Prior to the war, these procedures were completely free of charge and financed by the national nephrology program.

The study found that image-guided biopsy, external biliary drainage, and image-guided drainage rank second, third, and fourth, respectively. This can be explained by the fact that the former and subsequent operations were performed in the interventional radiology clinic rather than the interventional radiology theaters (catheterization laboratory). Interventional radiologists are not simply technologists. Interventional radiologists must view themselves as clinicians, seeing patients in clinic settings to discuss procedures after referral and at follow-up clinic appointments after the procedures have been completed [7]. In this context, our study found that 41% of the procedures were performed in the IR clinic, which was used as a common area to assess patients referred for IR procedures, follow up on patents underwent by producers, and perform US-guided procedures using a capable ultrasound machine with convex and linear probes and Doppler capabilities. During working hours, a staff nurse is assigned to the IR clinic, and after hours, a nursing staff member from the emergency department covers the cases. On the other hand, 59% of the procedures were completed in the catheterization laboratory, which is outfitted with a cutting-edge angiography machine.

Interventional radiology procedures can be performed in a variety of settings depending on the operation. Potential sites include dedicated theaters with cutting-edge angiography equipment, fluoroscopy rooms, and treatment rooms outfitted with ultrasound machines, CT scanners, and MRI scanners [8]. Any department that wishes to do angiography, embolization, or sophisticated non-vascular operations must have an interventional radiology theater (IRT) equipped with cutting-edge angiography technology. The IRT should ideally be located within imaging with access to anesthesia; while this is not required, it does provide interventional radiologists with access to all specialized imaging [9].

Interventional radiologists are responsible for educating trainees, other interventional radiologists, diagnostic radiologists, clinical colleagues, and the general public on the benefits of interventional radiology [7]. In Sudan, it was only used in hospitals in the capital. However, the lengthy conflict between 2023 and 2024 worsened the situation. As a result, this study investigates the distribution of IR facilities in Western Sudan during this difficult period marked by a significant breakdown in the healthcare system, the loss of basic necessities, extreme poverty, and the plight of refugees. This revealed that 78% of the participants were residents of North Kordofan State, with the remaining 22% split among the six adjacent states.

Especially Wet Kordofan and East Darfur. These patients were sent to our hospital

because they lacked the necessary facilities and staff to perform the treatments. We should examine socioeconomically challenged communities' affordability to pay for various sorts of operations [5].
The current study found that the majority of participants were low-income, with 57% earning less than $100 per month and 42% earning between $100 and $500 per month. Only 1% of members earn more than $1,000 USD per month. Valuable treatment choices improve quality and quantity of life, reduce complications, and improve patient experience while lowering costs (value = outcomes x safety x service/cost) [3]. Most interventional radiologists would likely agree that these are characteristics of the treatment our specialty delivers, as evidenced by the widespread use of interventional radiology (IR) techniques in the medical field. "Bread-and-butter" IR procedures, such as image-guided percutaneous drainage, needle biopsy, and central venous access, have replaced their surgical predecessors as standard diagnostic and therapeutic options [8]. However, current reimbursement trends do not support this. Despite rising demand for image-guided procedures, reimbursement for IR procedures has dropped 6.9% during the last eight years[9]. The transition to a payment-for-value paradigm necessitates that the value of IR care be made plain. In our survey, the majority of treatments (52%) cost between 101 and 500 USD, with 40% costing less than 50 USD. Only 5% of procedures cost more than $1,000 USD. Again, when compared to the global cost, these process fees were greatly reduced due to the condition of the conflict; the only disadvantage was that the participants brought the consumables themselves and bore the costs of payment and transportation.

Conclusion

To summarize, the interventional radiology service in western Sudan has experienced considerable hurdles and obstacles during the Sudan crisis. The majority of those requesting the service are middle-aged males. The growing urban population, as well as unemployment and the high cost of consumables, have all had a significant impact on service provision in Western Sudan. However, a large number of people received interventional radiology procedures at El-Obeid InternationalHospital.

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Authors contribution

- Bahar MEH: Conceptual, Administration, Data collection, Analysis, Final approval

-Salem NAE: Data manipulation, Analysis, Final Approval

-Ahmed HGA: Conceptual, Consultation, Writing, critical revision, Final Approval

Conflict of Interest

The authors declare no conflict of interest

Ethical Approval

Agreement from authorities at the catheterization laboratory and interventional radiology clinic was obtained from El-Obeid International Hospital (Eldaman).

The protocol of this research will be approved by the ethical committee at PMRCC. Approval Number:HREC0015/PMRCC.9/24

Consent

As per international standards or university standards, patient(s) written consent has been collected and preserved by the author(s).

Data availability

Data regarding this study available from the corresponding author.

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