Patient radiation doses and Diagnostic Reference Levels (DRLs) for interventional cardiology procedures in Sudan

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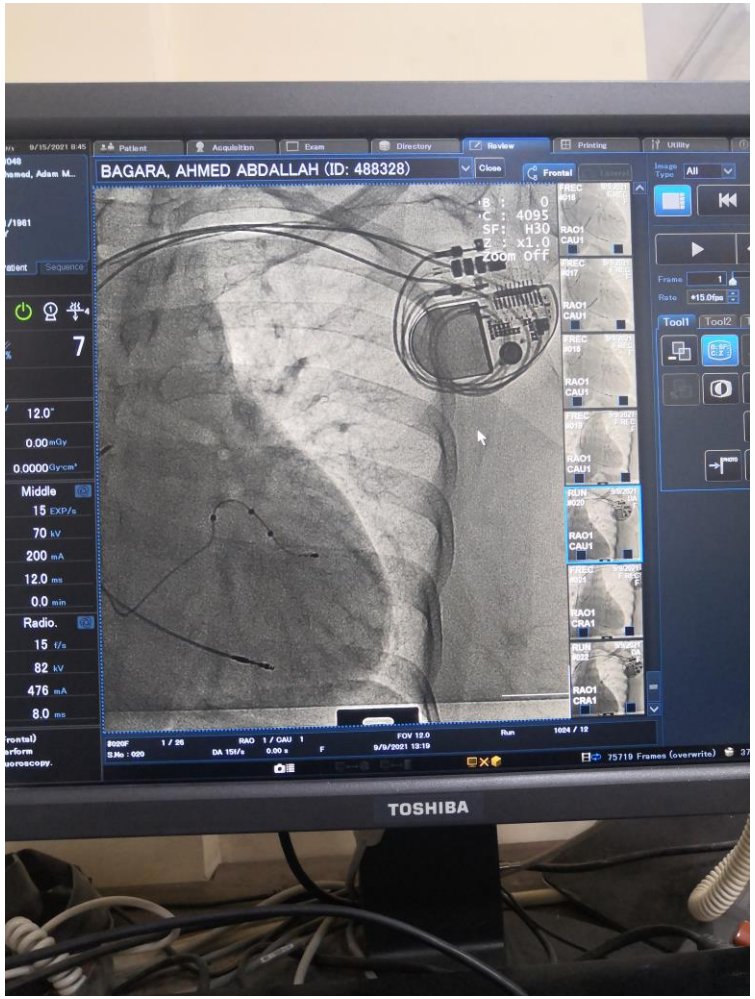
Outlines

- Introduction
- Objectives of the study
- Material and method
- Results and discussions
- Conclusion

Introduction

- Fluoroscopically guided interventional radiology has become a widespread technique used in various fields of medicine to diagnose or treat numerous diseases of the heart, the brain and spinal canal, as well as the vascular, urogenital and musculoskeletal systems.
- The global increase in both the number and complexity of cardiac catheterization procedures has created a growing concern in terms of the radiation-induced health effects (both deterministic and stochastic radiation risks) associated with fluoroscopically guided procedures involving extended fluoroscopic exposure times.



- In interventional cardiology (IC), the complexity of the procedures and production of images that are required expose the medical staff to ionizing radiation. Thus, a dosimetric control of radiation to people who are constantly involved in this type of environment is highly necessary.
- After long and complex procedures, patient skin dose might exceed the threshold of deterministic effects, resulting in radio dermatitis or alopecia.
- Moreover, the x-rays scattered from the patient expose staff in the catheterization laboratory to ionizing radiation.
- Therefore, IC practices have to be optimized in order to reduce these risks.

Examples of Injured Patients

- Case 1:
- Electrophysiological and ablation procedure
- Three attempts in 4 months, each with more than 100 minutes of fluoroscopy.
- After first attempt erythema observed by patient, but not recognized as due to procedure.

Erythemas on back healed. Arm lesion required grafting.

Case 2:

- percutaneous transluminal coronary angioplasty (PTCA) And stent placement of RCA.
- Involved 63 minutes of fluoroscopy and nearly 5000 frames of cine in LAO orientation with cranial tilt.

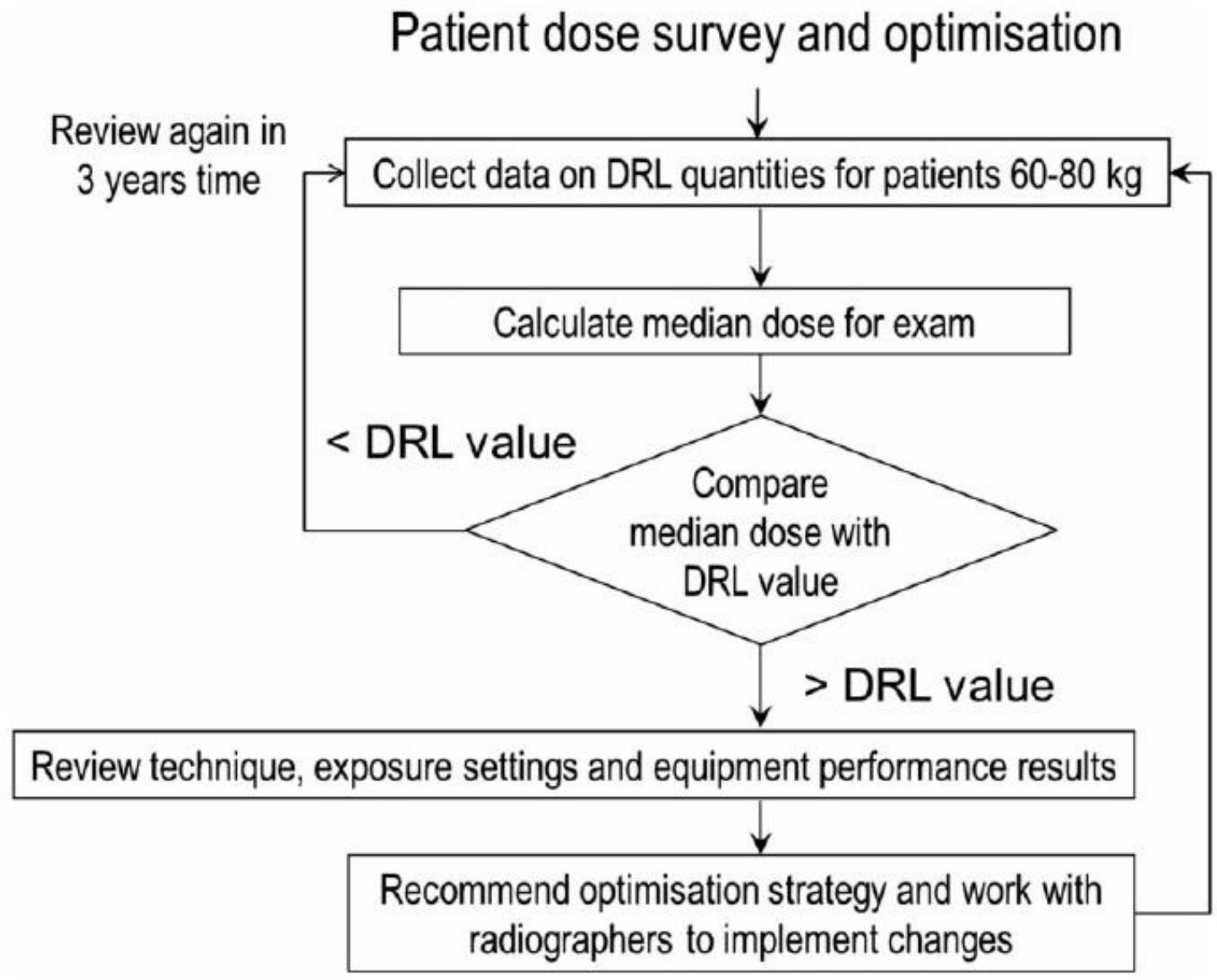
Case 3:

- PTCA : 51 minutes high-dose fluoroscopy, 74 seconds cine in 141 Kg man.
- Dose estimated retrospectively at 22 Gy.

Motivation for study

- Worldwide, interventional cardiology is the third largest contributor to the radiation dose of patients, after computed tomography (CT) and radiotherapy directly received by cancer patients (leyton et al. 2014).
- Radiation exposure may present a risk of carcinogenesis to the patient during their lifetime. Furthermore, the high radiation dose absorbed by the skin in a large patient or a prolonged procedure introduces the risk of skin tissue reactions, ranging from transient erythema to permanent damage requiring surgical intervention.
- Previous studies have suggested an occupational risk to staff with potential for development of posterior lens opacities and brain and neck tumors.
- Consequently, efforts need to be made to keep the radiation dose as low as reasonably achievable during the procedure, which would decrease any potential risk for staff and patients.

- Radiation protection and advisory bodies suggest that the radiation dose for radiological procedures should be monitored closely at local, regional, and national levels and should be revised as technology and techniques develop.


Patient dose survey and optimisation
Review again in 3 years time
Collect data on DRL quantities for patients 60-80 kg
Calculate median dose for exam
< DRL value
Compare median dose with DRL value
> DRL value
Review technique, exposure settings and equipment performance results
Recommend optimisation strategy and work with radiographers to implement changes

Objectives Of Study

To investigate the magnitude of patient radiation dose delivered to patients undergoing cardiovascular procedures

To assess the influence of existing technical operating parameters on radiation dose to patients and use the results to propose dose optimization measures.

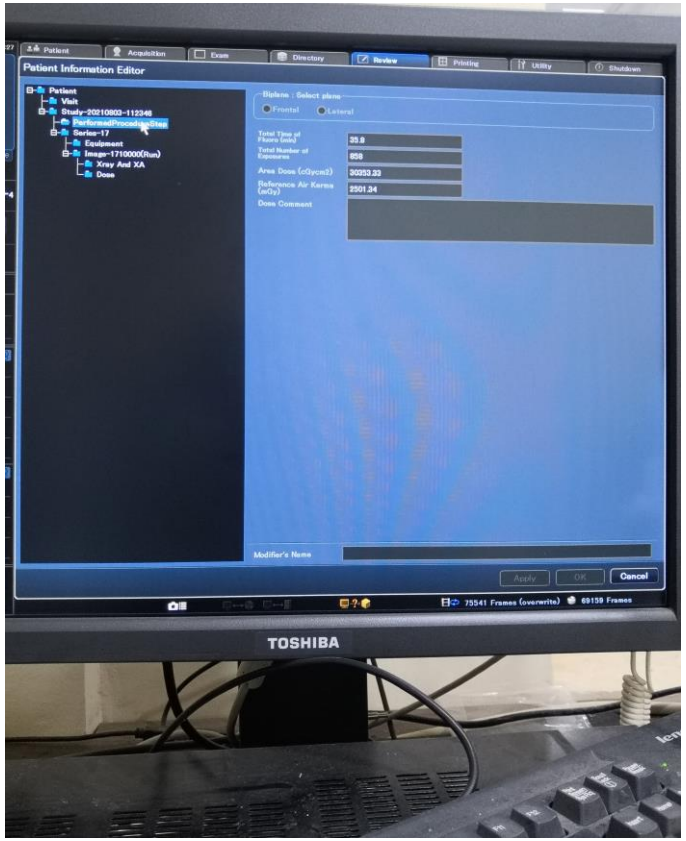
To compare and evaluate the current radiation protection practices among different interventional cardiology centers based on the current prevailing international standards

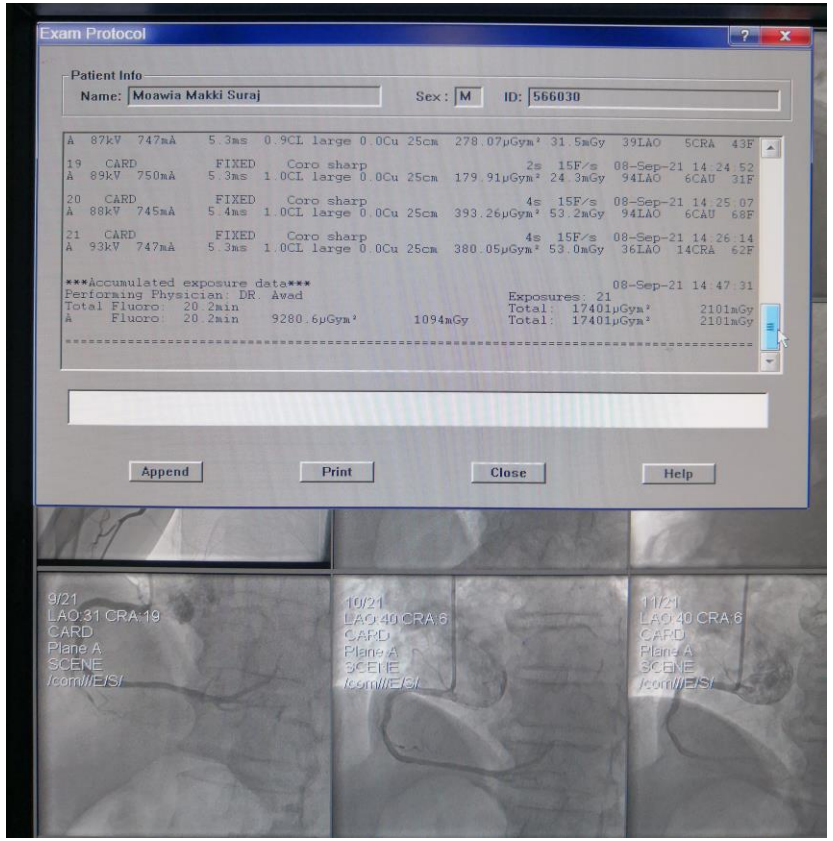
To use the results in deriving National DRLs (NDRLs) to be use used for future dose optimization.

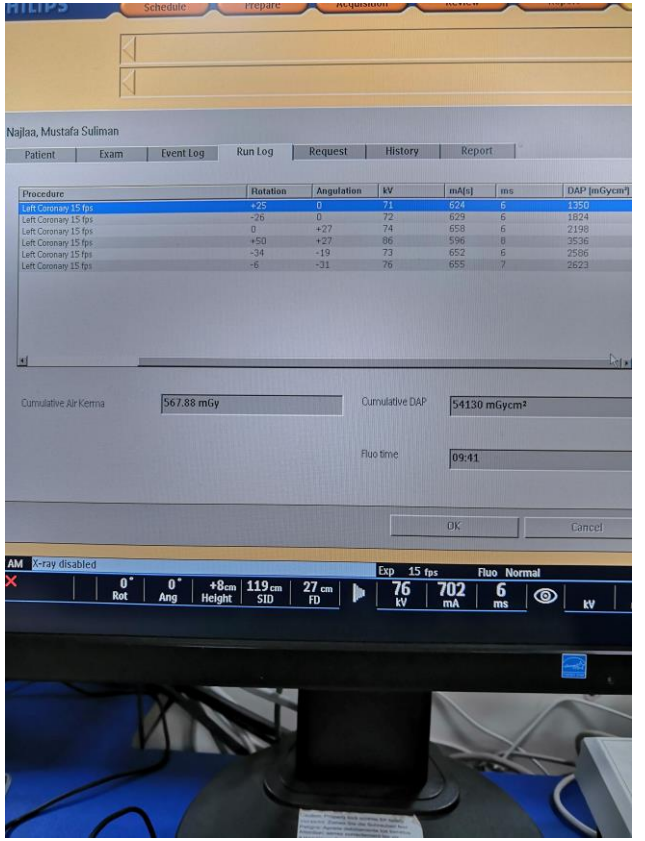
Material and method

- In this study we retrospectively collected and analyzed the exposure data of 3542 patients who underwent various cardiac catheterization procedures from May 2021 to October 2022.
- The patient-exposure related parameters displayed at the system console and from the patient dose summary reports produced by both cardiac X-ray systems and from medical reports were collected for each patient using a patient dose survey form prepared for this study.
- Knowing that the research has been ethically approved by the Deanship of Scientific Research at Al-Neelain University, as well as by the Ministry of Health in Khartoum State
- For each patient, the procedure identification, and patient demographic parameters were recorded: age, gender; in addition to the relevant dose information: Kerma Area Product (KAP) and Cumulative Air kerma (CAK), total number of cine images (NI), and Fluoroscopy Time (FT)

Data collections







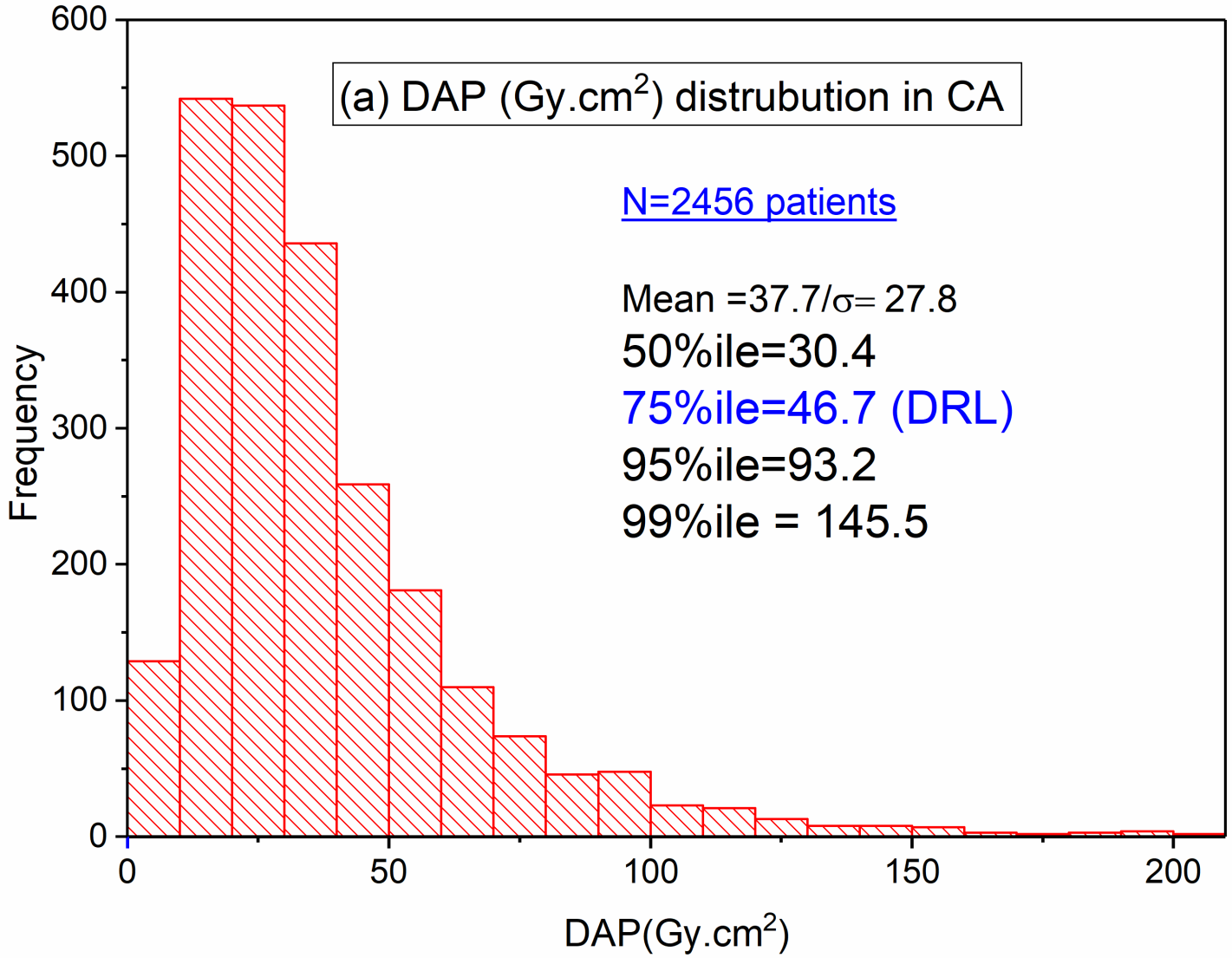
Material and method

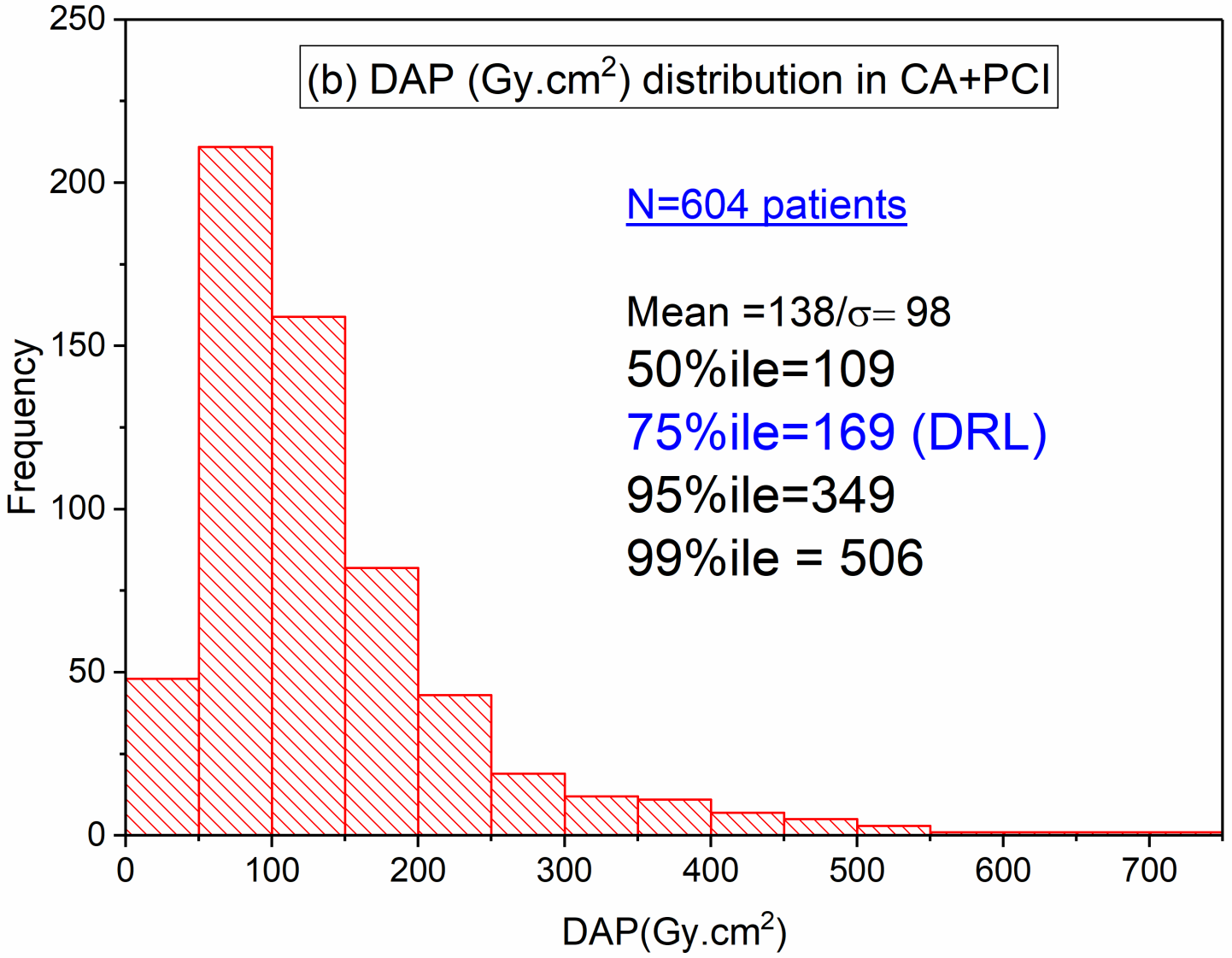
- Digital coronary angiography and interventions procedures including: Coronary Angiography (CA), Percutaneous Coronary Intervention (PCI), Coronary Angiography and Angioplasty with stent (CA + PCI), and Pacemaker (implantation or battery replacement
- All procedures were performed in six catheterization laboratory in Khartoum State on 2 Philips, 2 Siemens, and 2 Toshiba.
- Statistical analysis was performed using Excel

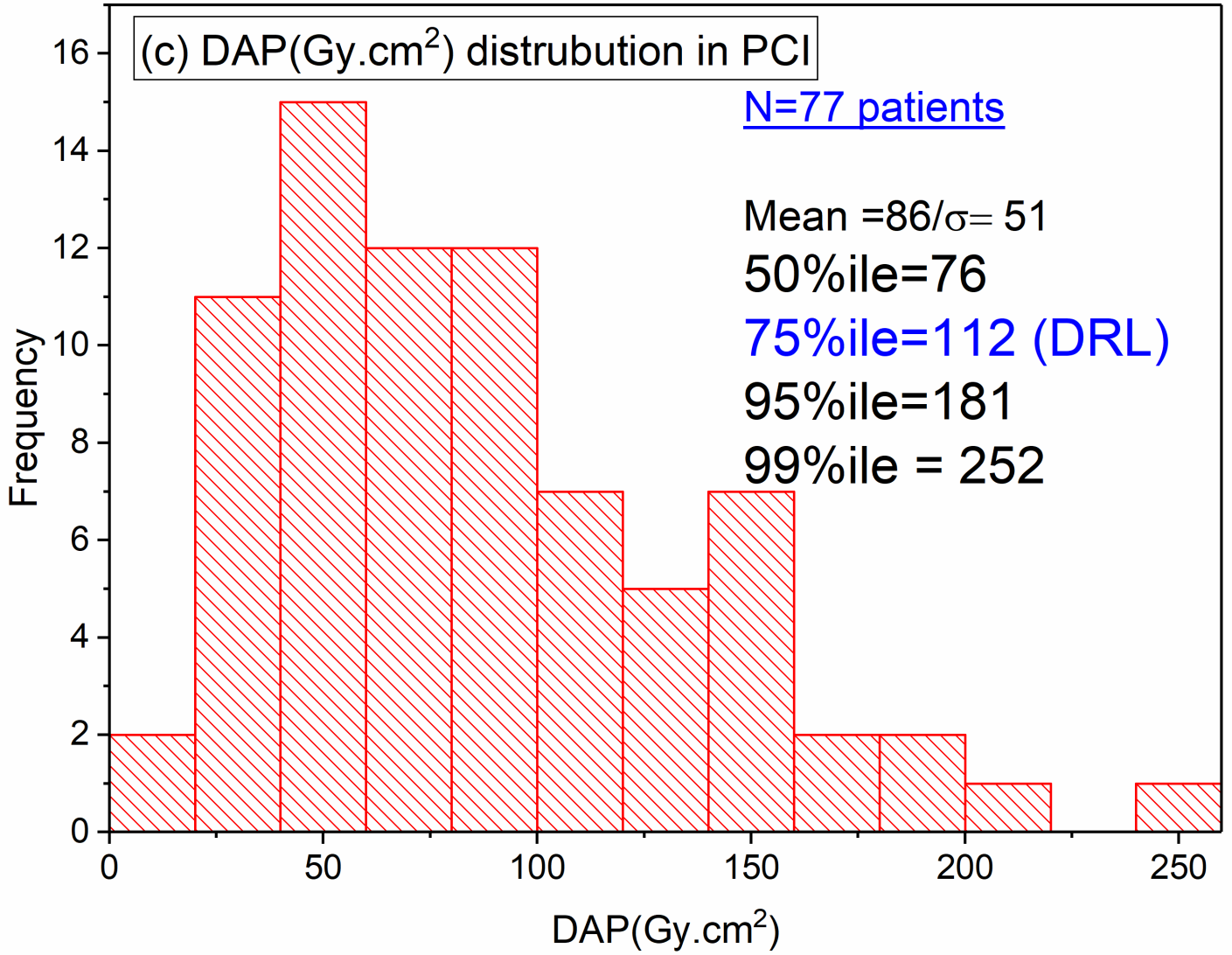
Results

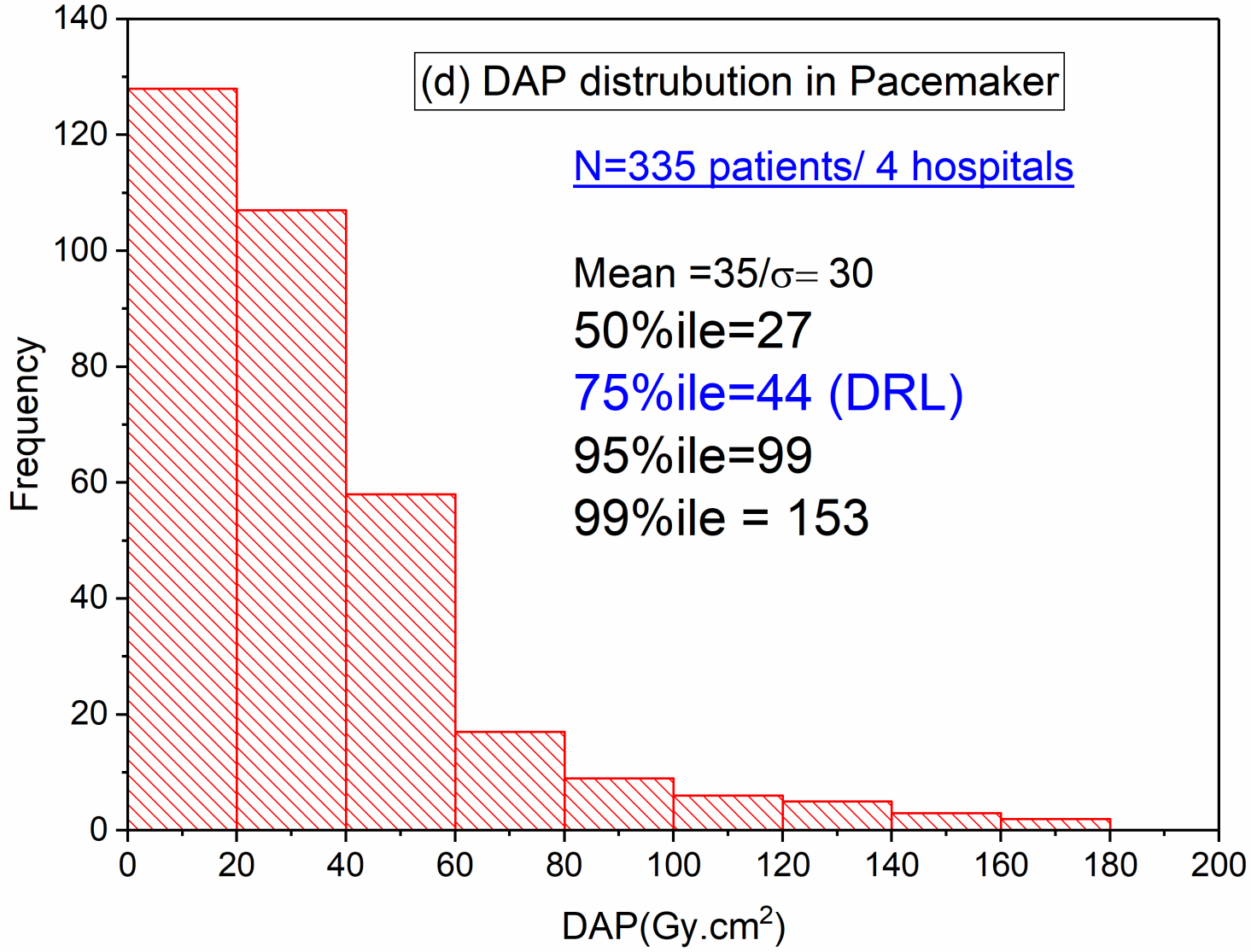
Machines data

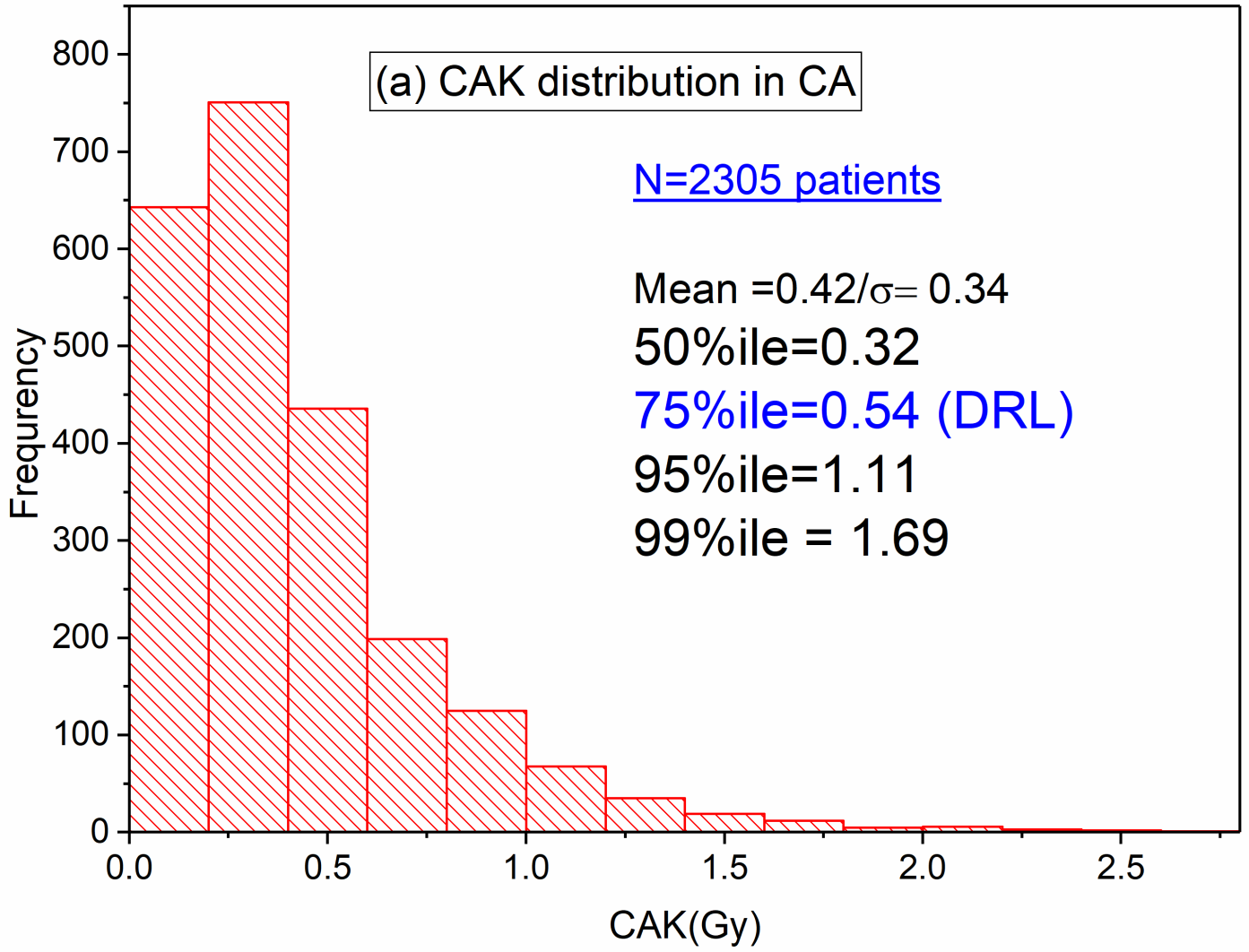
Hospital Name	Manufacturer	Model	Serial number	Country of origin	Year of installation	Last quality control date
H1	Philips	ALLURA XPER DF10	722026692	Netherlands		
H2	Toshiba	INFX-8000V, DSRX-T7445GFS, Manufactured April 2017	17D409R	Japan	Apr-2018	
H3	Toshiba	DFP-8000A, DSRX-T7345GFS, Manufactured May 2011	11E414U	Japan	Jun-2011	
H4	Siemens	Artis one, MEGALIX Cat Plus, Manufactured January 2019	(21) 692391871	Germany	Jun-2019	Feb-2021
H5	Philips	ALLURA XPER FD 20,System Module 001444, Manufactured October 2016		Netherlands		
H6	Siemens	Artis one, MEGALIX Cat Plus, VA10D180409, Manufactured May 2018	(21) 694151872	Germany	Jan-2021	

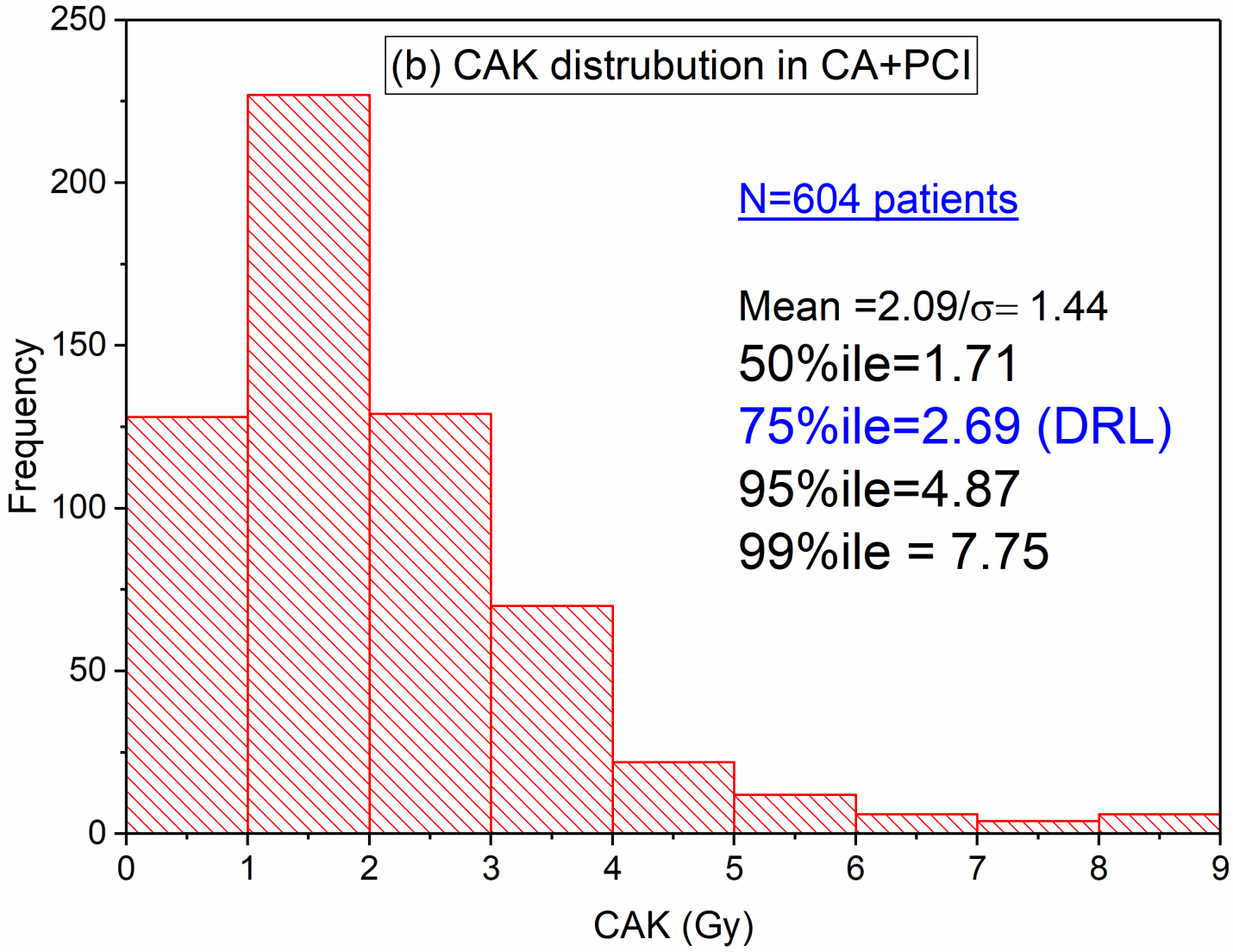

(a) DAP (Gy.cm^2) distrubution in CA
N=2456 patients
Mean =37.7/σ= 27.8
50%ile=30.4
75%ile=46.7 (DRL)
95%ile=93.2
99%ile = 145.5
Frequency
DAP(Gy.cm^2)
0
100
200
300
400
500
600
0
50
100
150
200

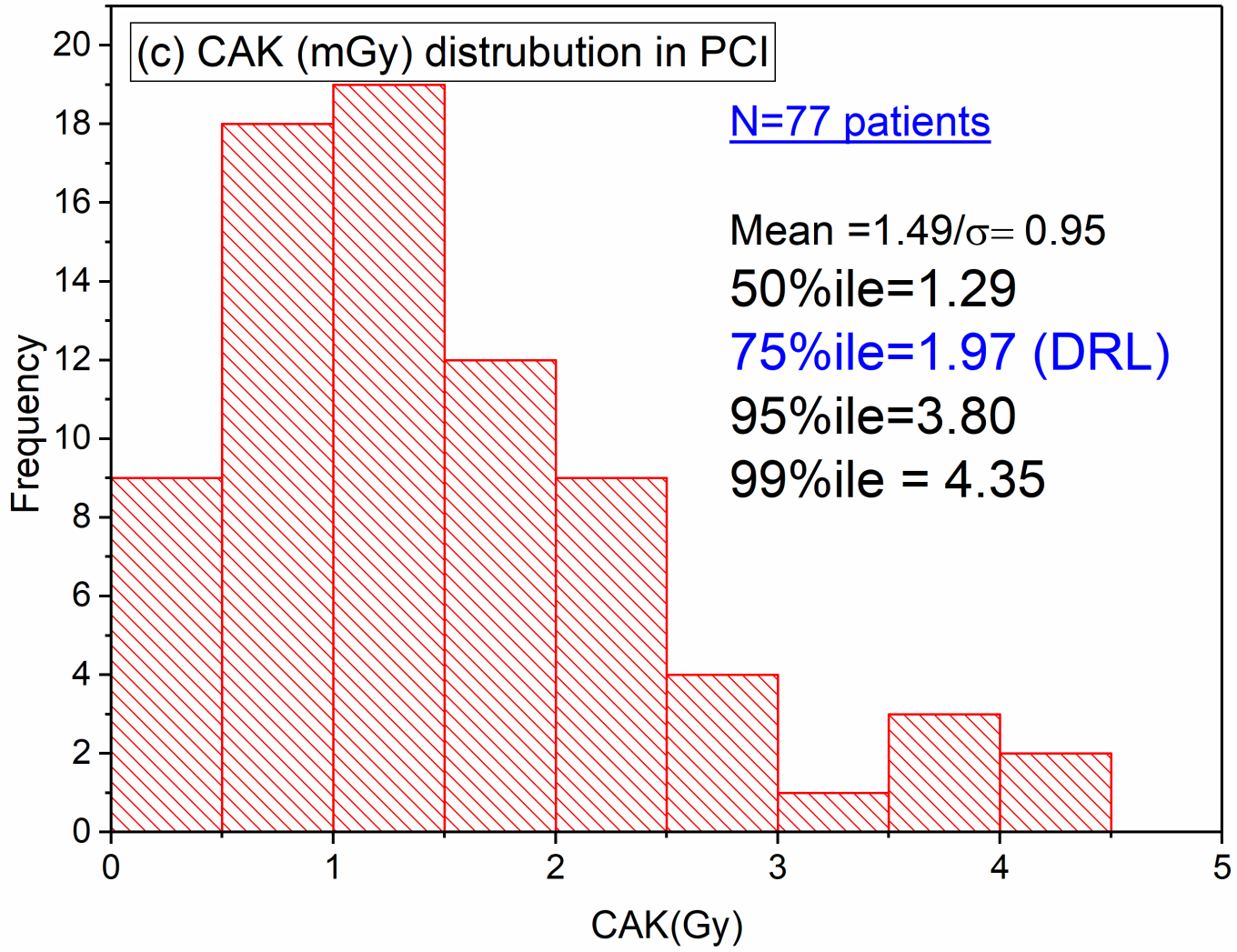

(b) DAP (Gy.cm^2) distribution in CA+PCI
N=604 patients
Mean =138/σ= 98
50%ile=109
75%ile=169 (DRL)
95%ile=349
99%ile = 506
Frequency
DAP(Gy.cm^2)
0
50
100
150
200
250
0
100
200
300
400
500
600
700

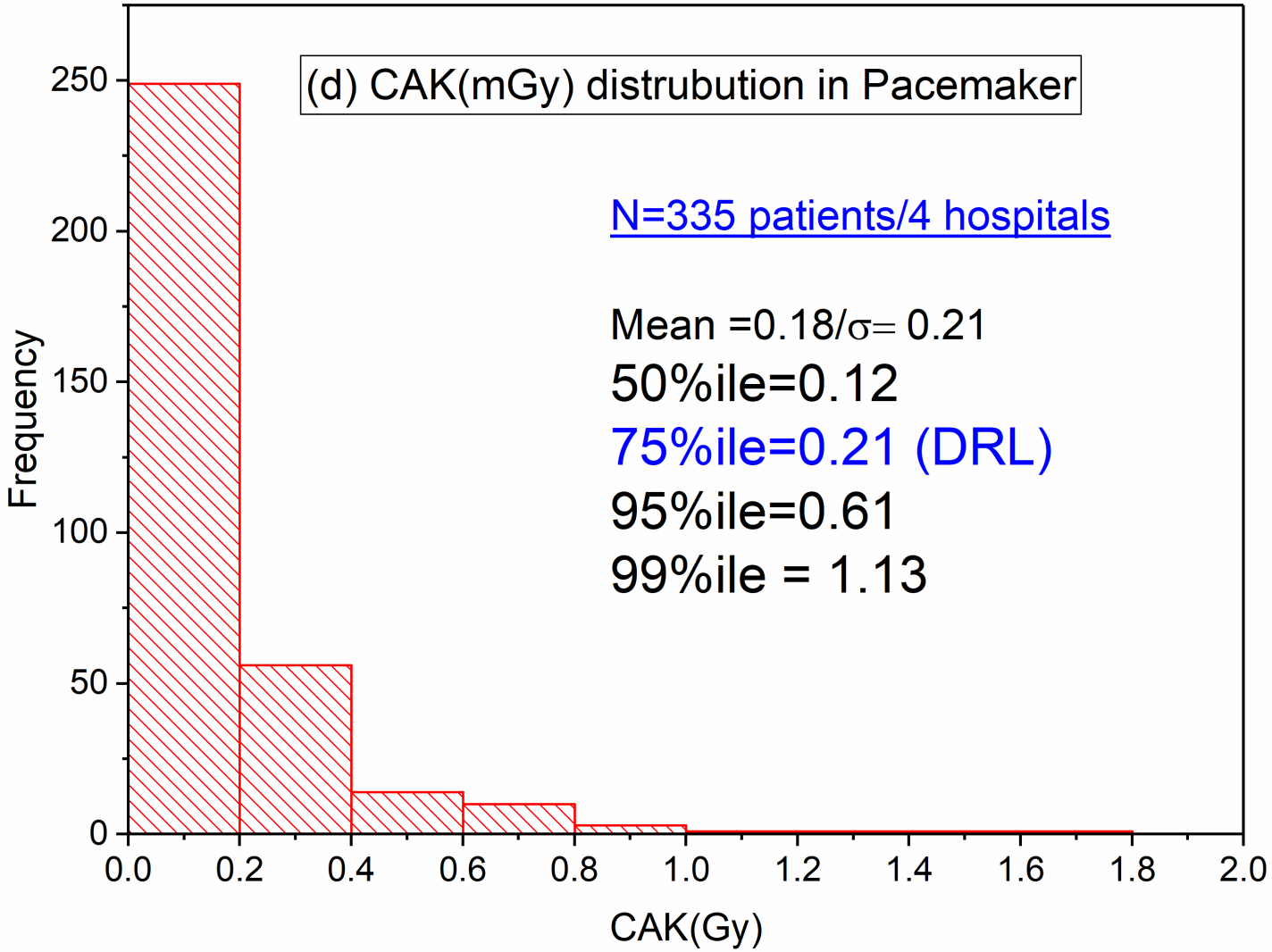

(c) DAP(Gy.cm^2) distrubution in PCI
N=77 patients
Mean =86/σ= 51
50%ile=76
75%ile=112 (DRL)
95%ile=181
99%ile = 252
Frequency
DAP(Gy.cm^2)
0
2
4
6
8
10
12
14
16
0
50
100
150
200
250


(d) DAP distrubution in Pacemaker
N=335 patients/ 4 hospitals
Mean =35/σ= 30
50%ile=27
75%ile=44 (DRL)
95%ile=99
99%ile = 153
Frequency
DAP(Gy.cm²)
0
20
40
60
80
100
120
140
160
180
200


(a) CAK distribution in CA
N=2305 patients
Mean =0.42/σ= 0.34
50%ile=0.32
75%ile=0.54 (DRL)
95%ile=1.11
99%ile = 1.69
Frequency
CAK(Gy)
0
100
200
300
400
500
600
700
800
0.0
0.5
1.0
1.5
2.0
2.5


(b) CAK distrubution in CA+PCI
N=604 patients
Mean =2.09/σ= 1.44
50%ile=1.71
75%ile=2.69 (DRL)
95%ile=4.87
99%ile = 7.75
Frequency
CAK (Gy)
0
50
100
150
200
250
0
1
2
3
4
5
6
7
8
9


(c) CAK (mGy) distrubution in PCI
N=77 patients
Mean =1.49/σ= 0.95
50%ile=1.29
75%ile=1.97 (DRL)
95%ile=3.80
99%ile = 4.35
Frequency
CAK(Gy)
0
2
4
6
8
10
12
14
16
18
20
0
1
2
3
4
5


(d) CAK(mGy) distrubution in Pacemaker
N=335 patients/4 hospitals
Mean =0.18/σ= 0.21
50%ile=0.12
75%ile=0.21 (DRL)
95%ile=0.61
99%ile = 1.13
Frequency
CAK(Gy)
0
50
100
150
200
250
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0

- **For CA:**
- The majority of patients receive relatively low DAP doses (below the median).
- However, there are outliers with significantly higher doses.
- Most coronary angiography procedures fall within a moderate range of CAK radiation exposure.
- However, there is significant variation, with some patients receiving higher doses.
- **For CA + PCI:**
- The majority of patients have relatively low DAP values.
- However, there's a tail of cases with much higher exposure.
- On average, patient exposure falls below the Diagnostic Reference Level.
- The median CAK falls below the Diagnostic Reference Level.
- However, there exists a subset of cases with significantly higher doses.

- **For PCI:**
- Most PCI patients have DAP values around or below the mean.
- A significant portion falls within a range close to the Diagnostic Reference Level (DRL) at the 75th percentile.
- However, there are outliers with exposure levels exceeding the 99th percentile mark.
- This distribution provides insights into typical radiation exposure during PCI procedures and highlights variations among different cases, which is crucial for establishing safety standards and optimizing patient care.
- Most PCI procedures adhere to acceptable radiation safety standards, with CAK doses around the mean and median values.
- However, there exists a subset of cases with significantly higher doses, reaching up to the 99th percentile.
- **For Pacemaker:**
- Most pacemaker implantation procedures fall within a moderate range of DAP radiation exposure.
- However, there is significant variation in exposure levels among patients.
- While many patients receive relatively low levels of radiation, some cases have considerably higher exposure.
- The median CAK falls below the Diagnostic Reference Level.
- However, there exists a subset of cases with significantly higher doses.

Conclusions

- Monitoring and optimizing radiation doses are crucial for patient safety during these procedures.
- Clinicians should monitor and optimize radiation doses to ensure patient safety.
- Balancing safety and efficacy remains crucial in these procedures to minimize radiation exposure while achieving successful outcomes.


THANKS FOR YOUR ATTENTION