

Original Research Article

Local Diagnostic Reference Levels Evaluation in Two Interventional Radiology Departments

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Abstract: Objective: Establish diagnostic reference levels for interventional radiology procedures common to Cardiology Institute and a private polyclinic and compare them with international standards. **Methods:** Study carried out in two interventional radiology units in Abidjan, Cardiology Institute and a private polyclinic. Coronarography, coronary angioplasty and uterine fibroid embolization were common procedures to both centers selected. Thirty patients per procedure were selected. Epidemiological data and dosimetric values (PDS, scan timing, cumulative doses) were noted. **Results:** Pds was 29, 86 Gy.cm², scan timing 7 min 82s, cumulative doses 457, 5 mGy for coronarography. Pds was 47, 77 Gy.cm²; scan timing 27 min 28s; cumulative doses 862 mGy for coronary angioplasty. Pds was 298, 45 Gy.cm²; scan timing 38 min 09s; cumulative doses 1162 mGy for uterine fibroid embolization. **Conclusion:** Differences were observed between the two sites due to differences in equipment. NRD were sometimes lower or higher than international values.

Keywords: Interventional radiology, Diagnostic reference levels, Kerma-area Product (KAP).

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INTRODUCTION

The Diagnostic Reference Levels (DRLs) are indicators using to improve the practice in medical radiology. They permit to assess the doses delivered to patients, to check the quality of equipments and procedures and possibly to drive control and corrective actions. They concern the most common and / or the most irradiating examinations.

Interventional radiology activities involve sometimes long X-ray exposure times leading to high cutaneous doses. In France since 2004, the establishment and use of reference levels have been extended to interventional radiology, for the most frequent procedures, in accordance with the requirements of European directive 2013/59 EURATOM [1].

Current DRLs vary from 38 Gy.cm² and 6 minutes of fluoroscopy for coronary angiography to 285 Gy.cm² and 68 minutes of fluoroscopy for embolization of a postpartum hemorrhage.

The aim of this study was to establish the DRLs for endovascular interventional radiology procedures common to two interventional radiology departments in Côte d'Ivoire and then compare it to international standards in order to propose a dose optimization approach.

METHODS

Our study was carried out in two interventional radiology units in our country, namely, Institut de Cardiologie d'Abidjan (ICA) and a private Polyclinic. It was retrospective and descriptive. We ran a comparison between the doses delivered to patients during interventional imaging procedures common to the two centers, namely diagnostic and therapeutic coronary angiography (coronary stenting) and uterine fibroid embolization over a period of three years. Patients whose dosimetry values were not available were excluded. For each of the three procedures, a sample of 30 patients per center, in chronological order, was included according to the DRL calculation methods, for a total of 180 patients.

For each patient, age, weight and height were noted as well as the dose-area product (DAP), the fluoroscopy duration, and the cumulative doses. The DRLs were determined for the following values: DAP (dose related to the surface in Gy.cm²), the fluoroscopy time (in minutes) and the cumulative dose (in mGy). They have been arranged in ascending order. DRL corresponded to the 75th percentile, that is to say the 23rd element. We also calculated for each procedure, the DRL of the DAP, the fluoroscopy time and the cumulative doses for the two centers included in the study (60 patients for each procedure).

The specialists who performed the procedures were the same at both centers except for uterine fibroid embolization where at ICA there were two doctors: one had about 20 years of experience; the other who assisted him, and who performed the procedures in the private center, had eight years of experience.

One of the interventional cardiologists had fifteen years of experience and four years for his

assistant who sometimes performed the procedures alone.

The procedures were performed on devices from General Electrics: INNOVA IGS 530 for ICA; the INNOVA IGS 520 for private polyclinic.

The data was collected using Excel 2010 software. The averages of the epidemiological data were calculated and the graphs were made using the Epi info software version 3.5.1.

RESULTS

I-ICA Interventional Radiology Unit

Diagnostic coronary angiography

The most represented age groups were [50-60 years] and [60-70 years]. The average age was 55.2 years with extremes ranging from 32 to 72 years. Most of the patients weighed [70-90] Kg. The average weight was 80.2 Kg. The average height was 169 cm with extremes of 158 to 185 cm.

Table-I: Distribution of patient doses for ICA diagnostic coronary angiography

	DAP(Gy.cm ²)	Fluoroscopy Time (min)	Cumulated doses (mGy)
1	3,99	2min 06s	68
2	5,39	2min 09s	82
3	5,78	2min 12s	92
4	5,84	2min 13s	100
5	6,2	2min 27 s	101
6	7,21	2min 44s	104
7	8,27	2min 56s	108
8	8,83	3min 03s	129
9	8,94	3min 44s	135
10	9,9	4min	149
11	10,28	4min 07s	164
12	10,71	4min 27s	172
13	11,52	5min 17s	174
14	11,65	5min 21s	176
15	12,43	5min 37s	178
16	12,81	5min 39s	182
17	13,02	6min 07s	187
18	13,76	6min 39s	195
19	13,89	7min 11s	203
20	16,28	8min 23s	228
21	19,5	8min 46s	254
22	19,99	9min 27s	270
23	22,85	10min 32s	301
24	23,76	10min 54s	315
25	23,97	12min 33s	358
26	25,5	12min 55s	361
27	27,48	14min 33s	415
28	31,74	14min 48s	455
29	47,51	17min 02s	643
30	68,59	20min 35s	768

The average DAP was 16.91 Gy.cm² with extremes ranging from 3.99 to 68.59 Gy.cm². The mean fluoroscopy time was 7 min 10 s with extremes ranging from 2 min to 20 min 35 s. The mean cumulative dose was 235.5 mGy with extremes ranging from 68 to 768 mGy. The DRLs for DAP, fluoroscopy time and cumulative doses were 22.85 Gy.cm², 10min 32s and 301 mGy respectively.

Angioplasty (angiography + stenting)

The most represented age group was that of [60-70 years] with an average of 59 years. The average weight was 80.8 Kg with extremes ranging from 62 to 106 Kg. The average patient height was 171 cm with extremes ranging from 146 to 187 cm.

Table-II: Distribution of doses for ICA coronary angioplasty

	DAP(Gy.cm ²)	Fluoroscopy time (min)	Cumulated doses (mGy)
1	9,34	7min 16S	169
2	12,42	8min 43S	211
3	12,82	9min 23s	232
4	14,45	9min 27s	242
5	19,99	10min 15s	270
6	22,63	10min 30s	361
7	3,74	10min 54s	371
8	24,55	11min 02s	376
9	27,48	11min 08s	386
10	28,37	12min 09s	397
11	29,34	12min 52s	483
12	32,98	14min 55s	509
13	34,01	14min 58s	509
14	34,36	15min 07s	521
15	34,74	16min 46s	544
16	35,41	20min 43s	581
17	39,06	21min 02s	597
18	39,32	22min 11s	624
19	48,11	22min 37s	672
20	48,44	25min 01s	681
21	51,42	26mon 03s	734
22	52,68	29min 22s	737
23	53,17	30min 11s	833
24	54,47	31min 04s	853
25	57,4	33min 08s	945
26	64,1	34min 51s	951
27	69,67	37min 58s	954
28	113,23	41min 27s	1554
29	134,76	42min 32s	1628
30	152,75	57min 30s	1798

The average DAP was 45.84 Gy.cm² with extremes ranging from 9.34 to 152.75 Gy.cm². The mean fluoroscopy time was 21min 54s with extremes ranging from 7min to 57min 3s. The mean cumulative dose was 657.43 mGy with extremes ranging from 169 to 1798 mGy.

The DRLs of DAP, fluoroscopy time and cumulative doses were respectively 53.17 Gy.cm²; 30min 11s and 833 mGy.

Embolization of uterine fibroids

The average age was 41 years with extremes of 29 to 52 years.

Table-III: Distribution of doses for embolization of uterine fibroids at ICA

	DAP (Gy.cm ²)	Fluoroscopy time (min)	Cumulated doses (mGy)
1	16,32	9min 50s	123
2	20,26	10min 47s	163
3	24,87	11min 15s	195
4	50,04	12min 03s	297
5	50,04	14min 27s	297
6	55,14	16min 01s	301
7	72,48	16min 26s	348
8	82,01	17min 58s	396
9	84,07	18min 36s	465
10	102,58	18min 36s	497
11	110,91	19 min 28s	596
12	127,31	20min 40s	776
13	133,15	20min 45s	836
14	134	21min 34s	854
15	158,14	21min 36s	855
16	159,27	25min 25s	921
17	171,2	25min 25s	983
18	174,7	26min	1020
19	183,49	26min 25s	1041
20	188,78	28min 10s	1196
21	202	28min 39s	1215
22	232,87	29min 52s	1230
23	282,02	29min 54s	1392
24	298,91	29min 58s	1484
25	352,02	36min 36s	1504
26	440,9	47min 22s	1532
27	603,33	58min 50s	2655
28	622,87	79min 06s	2865
29	677,13	153min	3490
30	678	154min	3903

The average DAP was 200.37 Gy.cm² with extremes ranging from 16.32 to 678 Gy.cm². The mean fluoroscopy time was 29 min 97s with extremes ranging from 9 min to 154 min. The mean cumulative dose was 1114.3 mGy with extremes ranging from 123 to 3903 mGy. The NRDs for PDS, fluoroscopy time and cumulative doses were 282.02 Gy.cm², respectively; 29min 54s and 1392 mGy.

II- Interventional radiology unit of the Polyclinic

Diagnostic coronary angiography

The average age was 56.1 years with extremes of 38 to 75 years.

The average weight was 88.5 Kg with extremes of 63 to 117 Kg.

The average height was 174 cm with extremes ranging from 150 to 194 cm.

Table-IV: Distribution of doses for coronary angiography at the Polyclinic

	DAP(Gy.cm ²)	Fluoroscopy time (min)	Cumulated doses (mGy)
1	8,18	2min 30s	132
2	8,2	2min 34 s	134
3	8,82	2min 45s	153
4	9,39	2min 48s	157
5	10,81	3 min 03s	198
6	11,27	3 min 21s	204
7	13,73	3 min 22s	246
8	14,21	3min 29s	270
9	17,31	3min 41s	321
10	19,98	3min 41s	322
11	20,06	3min 50s	330
12	20,71	4 min 04s	332
13	21,43	4min 08s	343
14	21,55	4min 24s	357

	DAP(Gy.cm ²)	Fluoroscopy time (min)	Cumulated doses (mGy)
15	22,19	4min 26s	361
16	22,5	4min 31s	379
17	22,63	4min 34s	387
18	23,44	4min 49s	390
19	23,59	5min 05s	410
20	23,69	5min 08s	425
21	24,83	5min 21s	431
22	29,3	5min 27s	546
23	36,87	5 min41s	614
24	38,04	6min 32s	846
25	42,88	7min 27s	852
26	45,66	10min 19s	891
27	46,54	22min 57s	904
28	48,67	32min 19s	998
29	54,14	33min 45s	1000
30	68,42	44min 01s	1125

The average DAP was 25.96 Gy.cm² with extremes ranging from 8.18 to 68.42 Gy.cm². The mean fluoroscopy time was 8 min 1s with extremes ranging from 2min 3s to 44min 01s. The mean cumulative dose was 468.60 mGy with extremes ranging from 132 to 1125 mGy. The DRLs for DAP, fluoroscopy time and

cumulative doses were 36.87 Gy.cm², 5min41s and 614 mGy respectively.

Angioplasty (angiography + stenting)

The average age was 57.6 years with extremes ranging from 35 to 80 years.

Table-V: Distribution of doses for coronary angioplasty at the Polyclinic

	DAP(Gy.cm ²)	Fluoroscopy time (min)	Cumulated doses (mGy)
1	2,47	3min 43s	168
2	2,98	6min 06s	177
3	4,64	6min 54s	188
4	8,61	10min 19s	194
5	9,28	12min 37s	235
6	12,1	12min 45s	249
7	12,73	12min 50s	310
8	12,79	12min 52s	339
9	13,63	13min 10s	371
10	14,63	13min 30s	412
11	16,37	14min 01s	445
12	18,06	14min 08s	487
13	20	14min 14s	523
14	20,67	25min 02s	568
15	22,24	16min 06s	639
16	24,42	17min 16s	652
17	29,72	17min 19s	689
18	32,48	18min 07s	747
19	35,23	18min 28s	760
20	36,97	19min 47s	789
21	38,04	19min 54s	846
22	39,84	20min 46s	880
23	42,38	24min 46s	891
24	45,66	25min 42s	904
25	48,67	25min 47s	980
26	49,67	29min 26s	998
27	50,06	31min 27s	1125
28	53,93	34min 52s	1170
29	58,22	34min 52s	1269
30	68,42	43min 16s	1568

The average DAP was 28.16 Gy.cm² with extremes ranging from 2.47 to 68.42 Gy.cm². The mean fluoroscopy time was 18 min 46s with extremes ranging from 3min to 43min 16s. The mean cumulative dose was 625.43 mGy with extremes ranging from 168 to

1568 mGy. The DRLs for DAP, fluoroscopy time and cumulative doses were 42.38 Gy.cm², respectively; 24 min 46s and 891 mGy.

Embolization of uterine fibroids

Table-VI: Distribution of doses for embolization of uterine fibroids

	DAP (Gy.cm ²)	Fluoroscopy time (min)	Cumulated doses (mGy)
1	17,73	4min 39s	31,57
2	30,89	7min 41s	124
3	40,02	10min 09s	194
4	50,09	10min 53s	272
5	57,98	14min 22s	304
6	59,99	15min 08s	361
7	63,29	20min 06s	405
8	74,85	20min 53s	437
9	75,93	20min 55s	479
10	87,7	24min 82s	484
11	99,65	26min 47s	556
12	105,78	28min 36s	644
13	118,42	29min 25s	697
14	145,29	29min 49s	758
15	146,64	31min 57s	841
16	162,9	32min 02s	991
17	188,77	32min 23s	1024
18	212,62	35min 06s	1110
19	227,49	35min 24s	1296
20	242,15	38min 57s	1540
21	252,93	43min 12s	1758
22	304,9	45min 04s	1841
23	314,88	48min 42s	2133
24	322,28	56min 18s	2561
25	499,25	83min 32s	3860
26	609	91min 51s	3875
27	768,16	126min 16s	5161
28	784,02	132min 26s	5395
29	1117,72	143min 35s	5473
30	1127,55	160min 58s	8323

The average DAP was 276.96 Gy.cm² with extremes ranging from 17.73 to 1127.55 Gy.cm². The mean fluoroscopy time was 46 min 52s with extremes of 4 min to 160 min 58s. The mean cumulative dose was 1764.28 mGy with extremes of 31.57 to 8323 mGy.

The DRLs for DAP, fluoroscopy time and cumulative doses were 314.88 Gy.cm², 48 min 42s and 2133 mGy respectively.

Table-VII: Summary of DRLs calculated at the ICA and at the Polyclinic (PC)

	Diagnostic coronary Angiography	Angioplasty	Embolization of Uterine fibroids
ICA			
DAP (Gy.cm ²)	22,85	53,17	282,02
Fluoroscopy time	10 min 32s	30 min 11s	29 min 54s
Cumulated doses (mGy)	301	833	1392
PC			
DAP (Gy.cm ²)	36,87	42,38	314,88
Fluoroscopy time (min)	5 min 41s	24 min 46s	48 min 42s
Cumulated doses (mGy)	614	891	2133

Table-VIII: DRLs for the two centers

	Diagnostic coronary Angiography	Angioplasty	Embolization of Uterine fibroids
DAP (Gy.cm2)	29,86	47,77	298,45
Fluoroscopy time (min)	7 min 08s	27min28s	38min09s
Cumulated doses (mGy)	457,5	862	1162

DISCUSSION

I- Comparison of data collected from the two centers

In coronary angiography, the DAP and the cumulative doses at the ICA are lower than those of the polyclinic except for the fluoroscopy time which was nearly identical. As the operators of the two centers are almost identical, this difference could be due to the equipment which is different in the two centers.

In angioplasty, the DAP and the fluoroscopy time at the ICA were slightly higher than those in the polyclinic except for the cumulative doses. This difference could be explained by the training duty at ICA where the main operator was frequently assisted by learning physicians.

For the embolization of uterine fibroids, the DRLs at ICA were all lower than those at the polyclinic. As the operators in these two centers are almost identical, this slight difference could be due to the equipment which is different in the two centers.

II- Comparison of our data to international values

In coronary angiography The DAP, the fluoroscopy time, the cumulative doses of our study were respectively 29.86 Gy.cm2; 7 min 8s and 457 mGy.

The DAP: In the Nada study [2], the DAP was 25.46 Gy.cm2, close to our value. In that of Khelassi-Toutaoui [3], it was 77 Gy.cm2, higher than ours. These differences could be due to the sampling which differs from one study to another (180 patients in ours; 460 in that of Nada [2] and 98 in that of Khelassi-Toutaoui [3].

Several other studies [4-11] have found values greater than ours, varying from 38 to 80 Gy.cm2. These differences could be related to the long experience of interventional cardiologists, the usual handling of the catheterization table and our significantly lower sampling than other studies.

Fluoroscopy time: the values observed in the studies of Nada [2] and Khelassi-Toutaoui [3] were respectively 5 min 30s and 7 min, lower than ours. Other studies [5-7, 9,10] have found fluoroscopy time values varying from 6 min to 8 min close to ours.

In coronary angioplasty the DAP, the fluoroscopy time and the cumulative doses of our study were respectively 47.77 Gy.cm2, 27 min 28s and 862 mGy.

The DAP: our value was lower than those of some authors in Africa [2,3] who were respectively 69.5 Gy.cm2 and 176 Gy.cm2.

It was also lower than the majority of those in international studies, Asia [4,5] United States [11] and Europe [6-10]. This could be related to the long experience of the interventional cardiologist.

Fluoroscopy time: its value in our study (27 min 28s) was slightly higher than that of certain studies in Africa [2,3], in Europe [7-10] and in the United States [11]. In France, IRSN in 2019 [6] noted 15 min. This difference could be related to the many variations of coronary arteries, potentially responsible for some difficulties during the procedure. As the public center is a university hospital, the training of trainee doctors could be a cause of the lengthening of the fluoroscopy time.

Embolization of uterine fibroids. The DAP, fluoroscopy time and cumulative doses of our study were respectively 298.45 Gy.cm2, 38min 9s, 1162 mGy.

The DAP: its value in our study was higher than those observed by Etard [12] (175 Gy.cm2) and Ruiz-Cruces [13] (214 Gy.cm2) but lower than that of Miller's study [14] which was 450 Gy.cm2.

Fluoroscopy time: our value was greater than those noted by Etard [12], Ruiz-Cruces [13] and Miller [14] which were respectively 29min; 31 min and 36 min.

Cumulative doses: its value in our study was greater than that observed by Etard [12] (800 mGy), Ruiz-Cruces [13] (256.5 mGy) but lower than that of Miller D [14] which was 3600 mGy.

CONCLUSION

The DRLs of the DAP, fluoroscopy time and cumulative doses in diagnostic angiography are respectively 29.86 Gy.cm2; 07min 08s and 457 mGy.

The DRLs of the DAP, fluoroscopy time and cumulative doses in coronary angioplasty are respectively 47.77 Gy.cm2; 27 min 28s and 862 mGy.

The DRLs of the DAP, fluoroscopy time and cumulative doses in fibroid embolization are

respectively 298.45 Gy.cm²; 38 min 09s and 1162 mGy.

Depending on the case, these values are slightly higher or lower than those observed in the literature. These local DRLs should be considered as a first approach to help optimize these procedures and their continuous review should be considered by the Nuclear Radiation Protection, Safety and Security Authority of our country.

Conflicts of interest disclosure

The authors declare no conflicts of interest.

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