INDIANA UNIVERSITY

OFFICE OF THE EXECUTIVE VICE PRESIDENT
FOR UNIVERSITY ACADEMIC AFFAIRS
University Environmental Health and Safety

IUPUI/IUMC Radiation Safety Office

30 April 2021

Mrs. Deborah A. Piskura
Senior Health Physicist
U.S. Nuclear Regulatory Commission – Region III
2443 Warrenville Road, Suite 210
Lisle, IL 60532-4352

Re: Follow Up of Inspection on 10/19/2020 and Request on 2/12/2021

NRC License No. 13-02752-03
Notification No. 54946

Dear Mrs. Piskura,

This letter is in response to your email request, dated 2/12/2021, regarding further evaluation of personnel dosimetry. I have listed your questions below, along with answers. Supplemental information and calculations are appended to this letter.

1. Specify the number, type, location, and frequency of exchange of dosimeters worn by your IR physicians (i.e., collar, torso/whole body, under lead, over lead, lead correction). Specify the methodology used by the dosimetry provider to assign dose for this user group (EDE1 or EDE2).

   General interventional radiologists are issued a single collar dosimeter (Landauer "Luxel+ Pa", OSL); authorized users for Y-90 radioembolization procedures are also issued extremity ("ring") dosimeters (Landauer "Saturn Ring", TLD). The collar dosimeters are to be worn outside of the lead apron at the collar level during all procedures; ring badges are only worn when performing radioembolizations procedures. These dosimeters are exchanged monthly. An EDE122 correction is applied to assign whole body doses to this group, which consists of dividing the collar badge DDE measurement by 5.6 to account for attenuation provided by lead apron wear [1]. Lead aprons are required to be a minimum of 0.5 mm lead-equivalent and are worn for all cases. For users that indicate that they wear leaded eyewear during procedures, a LDE17.5 correction is applied to the assigned lens of the eye dose, which consists of multiplying the collar badge LDE measurement by 0.175 to account for attenuation provided by the glasses.

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2. In your previous dose evaluation dated December 11, 2020, you used a methodology to assign dose to two individuals (IR1 and IR2) who were not wearing their dosimeters. Your evaluation used exposure history data from other IRs as examples of individuals who apparently wore their assigned dosimetry. For IR 2, you table description indicated that this table provided partial data, and IR2 appears to have years where he apparently failed to wear his dosimetry during the years 2016-2018. It appears that IR2 became more compliant in 2019 and 2020 at wearing his assigned dosimetry although you also indicated that the data for these years may be an underestimate of his exposure. Please include a reassessment of this dose history for the years 2019 and 2020.

3. Your dose reconstruction for IR1 and IR2 should include each physician's dose from fluoroscopy work. This dose should be as realistic as possible and supported with detailed information and your rationale for the methodology.

   Dose histories for both IR1 (years 2012-2020) and IR2 (years 2016-2020) are provided on the following pages in Tables 1 and 2. These dose reconstruction efforts have been fully re-performed using procedure data and exposure measurements, as detailed in Appendix A. These methods closely follow those used in previous submissions to the NRC [2].

4. Please provide additional information for occupational dose received from other NRC licensed or non-licensed facilities. For IR1, you indicated that he worked at IU Health Ball Memorial Hospital. This dose needs to be included in his estimates. For IR2, please clarify if he also worked at other facilities.

   IR1 works at IU Health Ball Memorial Hospital and IU Health West Hospital, performing interventional procedures only (no Y-90 use at these locations). Likewise, IR2 works at IU Health West. While the IUMC radiation safety office does not provide RSO services at these locations, procedures at these locations are tracked using the same software (Cerner) utilized at our facilities. The Interventional Imaging Manager for the IUMC sites was able to provide data for both physicians at all sites, which are incorporated in the dose reconstructions.

5. After the dose estimates are complete for IR1 and IR2, how will IU Health update/correct the dose history?

   The IUMC radiation safety office will work with the dosimetry provider to correct the dose history of these physicians by providing a copy (or portion of) this report. IUMC routinely works with the provider to perform similar corrections.

6. For the years 2012-2020, were annual reports (NRC Form 5 or equivalent) provided to these physicians?

   NRC Form 5 or equivalent forms have been provided to these physicians for all years they have been employed at facilities served by the IUMC radiation safety office. Updated/corrected forms will be re-issued following updates with the dosimetry provider.

Table 1. Dose estimates are provided for IR1. Estimated overexposures are indicated by red text.

Year	EDE (mrem)	LDE (mrem)	SDE, WB (mrem)	SDE, ME (mrem)
2012	5132	1842	16577	3329
2013	7082	2538	22874	3524
2014	4639	1660	14984	1430
2015	4876	1750	15748	3150
2016	4872	1751	15738	3766
2017	4641	1667	14989	3280
2018	4630	1658	14955	1738
2019	4998	1792	16145	2546
2020	4515	1619	14584	2343

Table 2. Dose estimates are provided for IR2.

Year	EDE (mrem)	LDE (mrem)	SDE, WB (mrem)	SDE, ME (mrem)
2016	251	102	810	367
2017	1107	456	3575	4127
2018	1165	478	3762	3977
2019	1239	498	4000	2939
2020	1067	431	3447	2922

Sincerely,

T. Michael Martin Digitally signed by T. Michael Martin
Date: 2021.04.30 13:15:55 -04'00'

T. Michael Martin, PhD, DABHP

IUPUI/IUMC Director of Health Physics & Radiation Safety Officer

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References:

[1] NCRP Report No. 122 "Use of Personal Monitors to Estimate Effective Dose Equivalent and Effective Dose to Workers for External Exposure to Low-LET Radiation"

[2] St. Luke's Regional Medical Center, Response to NRC – ML20219A337

[3] McCaffrey, J.P., Shen, H., Downton, B. and Mainegra-Hing, E. (2007), Radiation attenuation by lead and nonlead materials used in radiation shielding garments. Med. Phys., 34: 530-537. https://doi.org/10.1118/1.2426404

Appendix A

Dose Reconstruction Methodology and Calculations

Materials, Methods, and Assumptions

- Interventional procedure data was provided for both physicians for the time periods indicated. This data, in Tables B1 and B2 of Appendix B, show the type and number of procedures performed by both physicians at all sites, including both IUMC sites and others (i.e. IU Health Ball Memorial Hospital, IU Health West Hospital, and others within the IU Health system).

- As shown in Tables B1 and B2, this data consisted of over 13,000 procedure of 197 types for IR1, and over 5,000 procedures of 128 types for IR2. To simplify data analysis, procedures were categorized into groupings of similar type or duration (port/line/g-tube tunneled placement, non-tunneled/other placement, angiography/venogram/etc., and vascular embolization/thrombectomy/etc.). Within these groupings, fluoroscopy time was averaged for the highest procedure types by volume. These averaged fluoroscopy times were then applied to all procedures within that group. This data is shown in Tables A1 and A2.

- Retrieved fluoroscopy times provided do not separate between conventional/pulsed fluoroscopy modes and continuous/cineradiography/digital-subtraction-angiography (DSA) modes. A conservative estimate of 10% cine/DSA use and 90% pulsed use was applied to each unit of fluoroscopy time.

Table A1. Total number of cases and averaged fluoroscopy time per year and case type are shown for IR1. Total annual pulsed and cine/DSA times are also shown.

	2012	2013	2014	2015	2016	2017	2018	2019	2020
Vascular Embolization/Thrombectomy/etc. – 31.3 min per procedure									
No. of Procedures	142	188	127	124	124	159	139	158	159
Fluoro Time (min)	4444.6	5884.4	3975.1	3881.2	3881.2	4976.7	4350.7	4945.4	4976.7
Port/Line/g-tube Tunneled Placement – 2.5 min per procedure									
No. of Procedures	855	1144	946	1103	1238	1059	955	949	844
Fluoro Time (min)	2137.5	2860	2365	2757.5	3095	2647.5	2387.5	2372.5	2110
Angiography/Venogram/etc. – 25.4 min per procedure									
No. of Procedures	290	411	244	258	241	192	225	244	201
Fluoro Time (min)	7366	10439.4	6197.6	6553.2	6121.4	4876.8	5715	6197.6	5105.4
Non-tunneled/Other Placement – 1.5 min per procedure									
No. of Procedures	41	109	98	78	129	108	135	92	94
Fluoro Time (min)	61.5	163.5	147	117	193.5	162	202.5	138	141
Summary									
Total Fluoro Time (min)	14009.6	19347.3	12684.7	13308.9	13291.1	12663	12655.7	13653.5	12333.1
Standard Use (min)	12608.64	17412.57	11416.23	11978.01	11961.99	11396.7	11390.13	12288.15	11099.79
Cine/DSA Use (min)	1400.96	1934.73	1268.47	1330.89	1329.11	1266.3	1265.57	1365.35	1233.31

Table A2. Total number of cases and averaged fluoroscopy time per year and case type are shown for IR2. Total annual pulsed and cine/DSA times are also shown.

	2016	2017	2018	2019	2020
Vascular Embolization/Thrombectomy/etc. – 31.3 min per procedure					
No. of Procedures	24	196	193	112	92
Fluoro Time (min)	751.2	6134.8	6040.9	3505.6	2879.6
Port/Line/g-tube Tunneled Placement – 2.5 min per procedure					
No. of Procedures	96	388	461	1006	834
Fluoro Time (min)	240	970	1152.5	2515	2085
Angiography/Venogram/etc. – 25.4 min per procedure					
No. of Procedures	49	130	106	80	75
Fluoro Time (min)	1244.6	3302	2692.4	2032	1905
Non-tunneled/Other Placement – 1.5 min per procedure					
No. of Procedures	27	142	143	146	154
Fluoro Time (min)	40.5	213	214.5	219	231
Summary					
Total Fluoro Time (min)	196	856	903	1344	1155
Standard Use (min)	176.4	770.4	812.7	1209.6	1039.5
Cine/DSA Use (min)	19.6	85.6	90.3	134.4	115.5

- Scattered exposure rates were measured or extrapolated at two locations for both pulsed and cine/DSA modes using a phantom to simulate patient procedures and a Fluke 451P ion chamber. Conventional/pulsed dose rates are given at 50 cm, an estimate of physician location during normal procedures. Cineradiography/DSA dose rates are given at 100 cm. Typically, physicians leave the room during these exposures, although not in every instance. This methodology assumes the physician remains within the room and so is overly conservative. Measurements are provided in Table A3.

- Conservative estimates for attenuation [3] were applied to EDE calculations by assuming 120 kVp spectra and 0.5 mm of lead, as no shielding was used during the above experiments. This is overly conservative in that typical tube operating voltages for interventional procedures are in the 85-105 kV range, and that scattered radiation will be at lower energies. Estimates are provided in Table A3.

Table A3. Measured and corrected-for-shielding exposure rates are provided.

	Pulsed/Conventional Fluoroscopy Exposure Rate @ 50 cm	Cineradiography/DSA Exposure Rate @ 100 cm
Unshielded	0.45 mR/min	1.07 mR/min
Shielded	0.23 mR/min	0.44 mR/min

- Due to potential errors in calculating fluoroscopy time based on averaging over so many procedure types, all calculated EDE values were multiplied by a factor of 1.5 in an attempt to prevent underestimation. The EDE contribution from fluoroscopy is calculated by the following equation, where FT is fluoroscopy time, in minutes.

$$\mathbf{EDE_{(x\text{-}ray)} = 1.5 \times 0.97\ mrem/mR \times [(FT \times 0.9 \times 0.23\ mR/min) + (FT \times 0.1 \times 0.44\ mR/min)]}$$

- Lens dose contributions from fluoroscopy were calculated by multiplying the calculated unshielded exposure rate by 0.175 (i.e. LDE17.5 correction) to estimate LDE values. This is shown in the following equation:

$$\mathbf{LDE_{(x\text{-}ray)} = 1.5 \times 0.97\ mrem/mR \times 0.175 \times [(FT \times 0.9 \times 0.45\ mR/min) + (FT \times 0.1 \times 1.07\ mR/min)]}$$

- Shallow dose (whole body) contributions from fluoroscopy were estimated by applying a correction factor to the calculated EDE values. A correction factor of 3.23 was determined based on historical dosimetry data from other interventional radiologists at our locations by taking an average ratio between reported EDE and SDE values. This value is given by:

$$\mathbf{SDE,\ WB_{(x\text{-}ray)} = EDE_{(x\text{-}ray)}\ x\ 3.23}$$

- Shallow dose (extremity) contributions from fluoroscopy are assumed to be minimal when compared to Y-90 radioembolization use, as seen in our previously submitted report. Nevertheless, a small factor was applied via:

$$\mathbf{SDE,\ ME_{(x\text{-}ray)} = EDE_{(x\text{-}ray)}\ x\ 0.1}$$

Contributions from Radioembolization Procedures

- Contributions from Y-90 radioembolizations were taken into account using values derived from previous data and several assumptions. These are as follows:
    1) Average administration of 50 mCi.
    2) Source to physician distance of 100 cm
    3) ¼" (0.635 cm) of plastic shielding during 15 minutes of exposure while source is within the administration box, with a dose rate of 0.13 mR/hr @ 100 cm. The administration box is normally kept in a corner of the room until ready for administration, so this is a conservative estimate.
    4) No shielding while material is in transit through the catheter, with a dose rate of 30 mR/hr @ 100 cm
    5) Catheter transit time of 1 minute. In most cases, the vast majority of material is administered with the first flush, which typically takes less than 30 seconds.

- The EDE contribution from Y-90 exposure is given as follows:

$$\mathbf{EDE_{(Y\text{-}90)} = 1.5\ x\ 0.97\ mrem/mR\ x\ YPY\ x\ [(0.13\ mR/hr\ x\ 0.25\ hr) + (30\ mR/hr\ x\ 0.017\ hr)]}$$

where YPY is the number of Y-90 radioembolizations administered by the physician in question per year. YPY values are shown in Table A4.

- Lens dose contributions from Y-90 exposures were taken to be the same as the $EDE_{(Y\text{-}90)}$.
- Shallow whole body doses were estimated similarly to contributions from fluoroscopy, given by

$$\mathbf{SDE, WB_{(Y\text{-}90)} = EDE_{(Y\text{-}90)} \times 3.23}$$

- Shallow extremity doses from Y-90 procedures were estimated using previous data, reproduced below in Fig. A1. The relationship between number of Y-90 procedures and extremity dose show an acceptable correlation, as seen in the figure. Again, a factor of 150% was applied to prevent underestimation.

$$\mathbf{SDE, ME_{(Y\text{-}90)} = 1.5 \times (102.7 \times YPY - 178.02)}$$

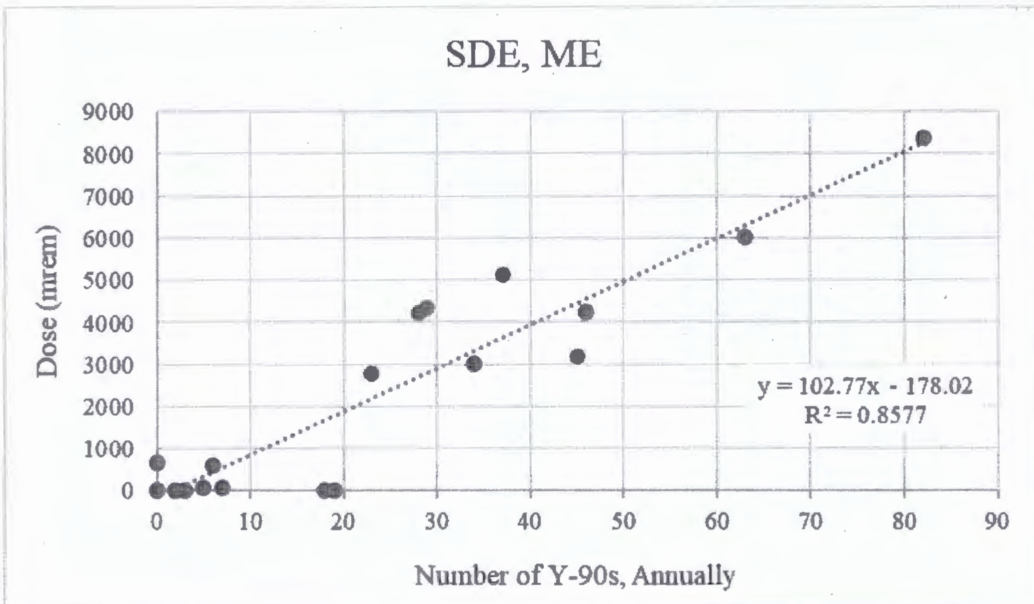

Fig. A1. Correlation between extremity dose and number of Y-90 radioembolizations per year (YPY).

Table A4. Number of Y-90 administrations per year (YPY) are given for each physician. The star (*) indicates estimates due to lack of data.

	2012	2013	2014	2015	2016	2017	2018	2019	2020
IR1	20*	20*	8	19	23	20	10	15	14
IR2	--	--	--	--	--	--	--	18	19

Appendix B

Table B1. Annual number and type of procedures for IR1.

Procedure Type	2012	2013	2014	2015	2016	2017	2018	2019	2020	Totals
IR ABD Paracentesis W/o Guidance	2					1				3
IR Ablation Therapy Endovenous Laser			25	11	21	8	8	6	9	88
IR Ablation Therapy Endovenous RF	1	3								4
IR Abscess Catheter Change	1	1	1	9	16	9	14	16	26	93
IR Abscess Drainage Soft Tissue w/Guid			1	3	3	8	7	3	3	28
IR Abscess Injection Thru Drainage Cath		1	2	4	2	2	1	2	2	16
IR Angio Thru Existng Cath for Follow Up	45	56	8	9			6	3	2	129
IR Angiography Adrenal Left	1						1			2
IR Angiography Adrenal Right							1			1
IR Angiography Com Carotid/Inom Ext		1							1	2
IR Angiography Com Carotid/Inom Ext Bil		1							2	3
IR Angiography Com Carotid/Inom Int		2		1		1			2	6
IR Angiography Com Carotid/Inom Int Bil								1	1	2
IR Angiography Extremity Bilateral	25	46	34	28	23	7	3	3	2	171
IR Angiography Extremity Left	29	29	19	38	25	16	18	15	22	211
IR Angiography Extremity Right	15	39	32	26	24	14	17	30	13	210
IR Angiography Internal Mammary	1	1		1				1		4
IR Angiography Intrnl Carotid Select		2			1		2		1	6
IR Angiography Pelvic	8	5	5	14	7	6	11	11	4	71
IR Angiography Pulmonary Selective Bilat	4	2	5	7	9	8	16	21	17	89
IR Angiography Pulmonary Selective Left	2	1			1		1		1	6
IR Angiography Pulmonary Selective Right				1	1	1	2	1	3	9
IR Angiography Renal 1st Order Bilat	10	14	9	10	11	12	11	8	5	90
IR Angiography Renal 1st Order Left	5	10	2	2	7	2	2	5	2	37
IR Angiography Renal 1st Order Right	5	5	7	1	3	2	4	10		37
IR Angiography Renal 2nd+ Order Bilat	1					1		1		3
IR Angiography Renal 2nd+ Order Left		1			1	1	1	1	1	6
IR Angiography Renal 2nd+ Order Right		1			1	1		3		6
IR Angiography Spinal Selective	1	2			2		1			6
IR Angiography Subclavian/Inom Vert									1	1
IR Angiography Thoracic Aorta/Arch		3	2			1	2			8
IR Angiography Vertebral Selective								1		1
IR Angiography Visceral	60	74	59	70	82	60	65	66	82	618
IR Angioplasty Aorta	1	1								2
IR Angioplasty AV Fistula/Graft Art Lt	5	3								8
IR Angioplasty AV Fistula/Graft Art Rt	5	2								7
IR Angioplasty AV Fistula/Graft Venous L	19	23								42
IR Angioplasty AV Fistula/Graft Venous R	16	10								26
IR Angioplasty Femoral/Popliteal Left	3	4								7
IR Angioplasty Femoral/Popliteal Right	2	8	1							11
IR Angioplasty Iliac INTL VSL	2									2
IR Angioplasty Renal or Visceral Artery	3	4			1					8

Procedure										
IR Angioplasty Tib/Prnl INTL VSL Left		5								5
IR Angioplasty Tib/Prnl INTL VSL Right		4	1							5
IR Angioplasty Venous	11	17						1		29
IR Aortagram Abdominal	22	40	4	3	4	23	31	33	14	174
IR Aortagram Thoracic	2				2		1	2	1	8
IR Atherectomy Tib/Prnl INTL VSL Lt		1								1
IR Biliary Drain Rmvl w/ INJ							1		2	3
IR Biliary Drainage Cath Change	6	6	9	11	24	21	16	11	14	118
IR Biliary Stent Plcmt New w/ Drain							1			1
IR Biliary Stent Plcmt thru Ext								1		1
IR Bronchial Angiogram Left	1		2	2	1			1	2	9
IR Bronchial Angiogram Right				3				2	2	7
IR Catheter Repair	1	1	1	1		1	1			6
IR Cecostomy Tube Placement Perc						1				1
IR Cent Vens Access Dev Contrst Inj Eval	1	2		2	1	1	2	2		11
IR Cent Vens Cath Plcmt Nontunnl US Guid	123	148	161	147	187	139	130	124	116	1275
IR Cent Vens Implant Port Plcmnt US Guid	16	36	53	65	62	53	48	60	83	476
IR Central Venous Cath Revisn or Replcmt	47	63	55	44	60	47	42	21	34	413
IR Central Vens Cath Plcmt Tunnl US Guid	117	201	182	199	211	221	202	179	149	1661
IR Cholangiogram T Tube Thru Ext Cath	4	3	4	14	5	5	2	7		44
IR Cholecystostomy		1	4	11	16	9	15	16	7	79
IR Conversion G to GJ Tube Perc	23	65	20	11	5	4	3	6	4	141
IR Convert Nephrostomy to NU Stent Lt								1	1	2
IR Convert Nephrostomy to NU Stent Rt								1	1	2
IR D or J Tube Replacement Perc	1	4	13	12	14	18	17	17	6	102
IR Declot by Thrombo of Vascular Access	2		2		1	1		2	1	9
IR Dialysis Access Declotting Left	5	9	16	13	18	3		1		65
IR Dialysis Access Declotting Right	4	10	15	8	5	2				44
IR Drain Cath w/Guid Kid/Lvr/Spln			1	3	1	2	2	1	1	11
IR Drain Cath w/Guid Lung/Mediast				2	2	3	2		1	10
IR Drain Cath w/Guid Perit/Retro				11	14	10	12	9	6	62
IR DUOD JEJ Tube Placement Perc			2	1	1			2	2	8
IR Embolization Extracranial			1			1				2
IR Endovascular Repair of AAA or Dissctn						1	1			2
IR Feeding Tube Removal	1			3	1				2	7
IR Fistula Sinus Tract Study				1	1	1		1		4
IR Fistulagram Accss/NonDirect Punctr Lt	3	5	3	5	5	1	1			23
IR Fistulagram Accss/NonDirect Punctr Rt	3	5		2	1	3	1			15
IR Fistulagram Ndl/Cath Direct Punctr Lt	64	73	67	93	128	57	31	39	19	571
IR Fistulagram Ndl/Cath Direct Punctr Rt	35	49	34	56	61	22	8	18	9	292
IR Fistulagram/Declot/PTA Lt						12	8	5	3	28
IR Fistulagram/Declot/PTA Rt						5	9	5	2	21
IR Fistulagram/Declot/Stent Lt						4	3	3	1	11
IR Fistulagram/Declot/Stent Rt						6	2		1	9
IR Fistulagram/PTA Lt						18	18	22	15	73

IR Fistulagram/PTA Rt						13	15	21	6	55
IR Fistulagram/PTA/Stent Lt						3	7	2	1	13
IR Fistulagram/PTA/Stent Rt						7	3	2	2	14
IR FL Guid CVA Dvce Plcmt Rplcmt or Rmvl	192	167	1							360
IR FL Guid for Needl Plcmt Bx Asp or Inj	3	1		1			4	7	6	22
IR FL Guided Drainage (Non Pleura)		1								1
IR Fluoro Interventional up to 1 hour	16	17	22	35	10	11	14	17	13	155
IR Fluoro Loopogram Antegrade		1								1
IR G or C Tube Replacement Perc	7	7	15	23	28	21	21	21	17	160
IR G Tube Change Perc No Imag w/ tract								1		1
IR G Tube Change Perc No Imag w/o tract								2	2	4
IR GJ Tube Replacement Perc	28	48	43	81	80	58	56	47	57	498
IR Guided Pleural Drain/Chest Tube		1			3	7	5	8	11	35
IR Guided Removal Intrvas Foreign Body								2		2
IR Guided Thoracentesis		1	1	4	1	4	6	3	3	23
IR Guided Thoracentesis Bilat						1				1
IR Injection Any GI Tube Perc	2	1			2	3	1	3	4	16
IR Insert Tunneled Cath Peritoneal		6	7	6	7	7	4	3	8	48
IR Insert Tunneled Cath Pleural	6	5	2	7	8	12	12	11	10	73
IR Insertion Stent Fem/Pop INTL VSL Rt			1							1
IR Insertion Stent Iliac INTL VSL	2	11	3							16
IR Insertion Stent Tib/Prnl INTL VSL Rt		1								1
IR IVC Filter Plcmnt	37	41	41	56	33	26	38	17	17	306
IR IVC Filter Retrieval Remove	7	14	13	13	34	21	20	13	10	145
IR Lymphangiogram Extremity Bilateral					2					2
IR Lymphangiogram Extremity Right									2	2
IR Lymphangiogram Pelvic Abdominal				1			2		4	7
IR Mech Rem Intrlumnl Obstr Mtrl CVA Dev		1				1				2
IR Mechanical Thrombectomy Venous	2	6	10	5	7	7	17	44	34	132
IR Mechanicl Thrombect NonCoronary Artrl	2	1			1	1	3	10	33	51
IR Neph Tube Removal with FL Guidance Lt			1		2					3
IR Neph Tube Removal with FL Guidance Rt			1		1	1				3
IR Neph Ureteral Stent NU Reml/Repl Bil		1		2			3			6
IR Neph Ureteral Stent NU Reml/Repl Lt						1	2	1		4
IR Neph Ureteral Stent NU Reml/Repl Rt			1		2			3	2	8
IR Nephrostogram Antegrade Lt	4	5	3		1	7				20
IR Nephrostogram Antegrade Rt	1	3	4	1	2	1		4	1	17
IR Nephrostogram Thru Existing Cath Lt	8	3	2	8	5	3		1	2	32
IR Nephrostogram Thru Existing Cath Rt	6	2	2	3	5	1	2	2	1	24
IR Nephrostomy Drainage Tube Change Left	1	4	6	7	12	10	5	13	10	68
IR Nephrostomy Drainage Tube Change Rt	2	2	1	2	2	3	7	15	8	42
IR Nephrostomy Tube Rmvl w FL Guid Bil						1			1	2
IR Perc Abscess Drainage Cath Placement	3	7	3	2	1			5	5	26
IR Perc Biliary Access							1	1	1	3
IR Perc Biliary Cath Placement External			2			1		1	2	6

IR Perc Biliary Cath Plcmt Int and Ext	1	3	2	2	5		5	3	6	27
IR Perc Gastrostomy Tube Placement	37	100	75	64	104	88	91	62	68	689
IR Perc Nephro Ureteral Stent Plcmt Lt						1	3	2	1	7
IR Perc Nephro Ureteral Stent Plcmt Rt						1	3		2	6
IR Perc Nephrostogram Tube Placement Lt	9	11	10	19	15	24	17	23	19	147
IR Perc Nephrostogram Tube Placement Rt	5	10	9	8	10	11	18	16	18	105
IR Perc Transhepatic Cholangiogram	1	2	2	7		1	1	4	2	20
IR Perc Transhepatic Portagram w/o Hemo		1								1
IR Perc Transhepatic Portagram with Hemo									3	3
IR Perc Ureteral Stent Placement Left	1			2		1	1	1		6
IR Perc Ureteral Stent Placement Right			2	1	2	1			2	8
IR Perc Ureteral Stent Reml and Repl Bil									1	1
IR Perc Ureteral Stent Rmvl and Repl Lt					1				1	2
IR PICC w/ Imaging 5 yr and older								4	6	10
IR Pleural Cath W/Cuff Removal Tunneled	1	1					1		2	5
IR Reposition Peritoneal Dialysis Cath	2	1	3	1	3	1	1	3	1	16
IR Rt Heart Catheterization w Pressures	1					1				2
IR Sclerotherapy Fluid Collection							2			2
IR Sclerotherapy Multiple Left			1				1			2
IR Sclerotherapy Multiple Right			1			1	1			3
IR Sclerotherapy Single Left			7		5	1			1	14
IR Sclerotherapy Single Right			2	1	1			3		7
IR Stent Placement Carotid with Filter		6	6	6	10	8	21	15	6	78
IR Stent Placement Carotid wo Filter				2				1		3
IR Stent(s) Place Intravasc 1st Artery						2	4	1	3	10
IR Stent(s) Place Intravasc 1st Vein					1	2	3	3	1	10
IR Surgical Neph Access Plcmt New								1		1
IR Thrombin Injection Extremity Left					2		2	1		5
IR Thrombin Injection Extremity Right		1	2		3		6	1	3	16
IR Thrombolysis Art/Vein ea Addl Day		4	6	15	1	8	5	4	2	45
IR Thrombolysis Arterial Initial Day		1	3	10	4	9	11	7	1	46
IR Thrombolysis Cessation Cath Remove		3	8	16	5	16	10	10	1	69
IR Thrombolysis Venous Initial Day		1	3	2	1	2	2	2		13
IR TIPS Insertion	2	4	9	5	6	10	13	6	4	59
IR TIPS Revision		1	6	1	1	4	2	7	6	28
IR Transcath Plcmt Intrvsclr Stent	1									1
IR Transcath Therapy Inf or Thrombolysis	4	3	3		1		1			12
IR Transcatheter Biopsy	1									1
IR Transcatheter Therapy Embolization	53	71	20	1		1				146
IR Transjugular Liver Biopsy US Guided	3	4	3	5	4	4	5	6	9	43
IR Tunneled Catheter Removal	38	58	85	53	79	69	47	60	36	525
IR Tunneled Port Removal	9	13	7	17	19	12	11	15	15	118
IR Ureteral Stent Plcmt w/Neph Tube Lt									1	1
IR Ureteral Stent/ Ileal Conduit Chg Lt				1	3	5	6	4	1	20
IR Ureteral Stent/ Ileal Conduit Chg Rt						1				1

IR Ureteral Stentogram and or Plcmt Rt				1	1					2
IR Uterine Fibroid Embolization Complt	5	4	2	3	3	9	14	6	4	50
IR Vasc Embo w/Guid Hemrhg/Lymph Extrav			5	8	14	26	11	14	19	97
IR Vasc Embo w/Guid Tumor/Isch/Infarct			12	27	42	32	20	25	29	187
IR Vascular Embo w/Guid Art/AVM/Aneurysm			9	6	5	12	13	5	7	57
IR Vascular Embo w/Guid Venous				9	7	8	4	5	1	34
IR Venogram Adrenal Bilateral	1	2			2	1				6
IR Venogram Adrenal Left						1				1
IR Venogram Extremity Bilateral	27	32	18	10	8	4	5	4	4	112
IR Venogram Extremity Left	2	8	12	9	9	8	3	6	3	60
IR Venogram Extremity Right	2	3	8	5	5	5	5	2	1	36
IR Venogram Hepatic with Hemodynamics	1	1	1	3			1	1	1	9
IR Venogram Hepatic without Hemodynamics			1					1		2
IR Venogram Inferior Vena Cava IVC	9	10	8	5	6	5	5	3	3	54
IR Venogram Renal Bilateral	2	1								3
IR Venogram Renal Left	1	1								2
IR Venogram Renal Right	1									1
IR Venogram Superior Vena Cava SVC	6	14	8	8	3	9	9	5	6	68
IR Venous Fibrin Sheath Stripping		3								3
IR Venous Sampling	1	1		2	3	3	1	3	2	16
Totals	**1349**	**1897**	**1425**	**1569**	**1729**	**1519**	**1447**	**1430**	**1284**	**13649**

Table B2. Annual number and type of procedures for IR2.

Procedure Type	2016	2017	2018	2019	2020	Totals
IR Abscess Catheter Change	3	20	21	25	29	102
IR Abscess Drainage Soft Tissue w/Guid	2	4	6	3	4	19
IR Abscess Injection Thru Drainage Cath		6	2	6	3	17
IR Angio Thru Existng Cath for Follow Up		1		1		2
IR Angiography Adrenal Right						1
IR Angiography Extremity Bilateral					1	1
IR Angiography Extremity Left	2	1	2	3	2	10
IR Angiography Extremity Right				3	2	5
IR Angiography Pelvic	2		4	2	7	15
IR Angiography Pulmonary NonselectivRt		1				1
IR Angiography Pulmonary Selective Bilat			1	2	2	5
IR Angiography Pulmonary Selective Left					1	1
IR Angiography Pulmonary Selective Right	1	1				2
IR Angiography Renal 1st Order Left			3			3
IR Angiography Renal 2nd+ Order Left		1	2			3
IR Angiography Renal 2nd+ Order Right		1			1	2
IR Angiography Subclavian/Inom Vert			1	1		2
IR Angiography Visceral	17	52	38	39	45	195
IR Aortagram Abdominal				1		1
IR Biliary Drain Rmvl w/ INJ	4	6	9	5	9	35
IR Biliary Drainage Cath Change	18	34	69	82	66	270
IR Biliary Stent Plcmt New w/ Drain		2	1		1	4
IR Biliary Stent Plcmt New w/o Drain	1			3		4
IR Biliary Stent Plcmt thru Ext		1		3	1	5
IR Bone Tumor RF Ablation INCL CT			1			1
IR Bronchial Angiogram Left				1		1
IR Bronchial Angiogram Right		1			2	3
IR Catheter Repair	1			1		2
IR Cent Vens Access Dev Contrst Inj Eval					2	2
IR Cent Vens Cath Plcmt Nontunnl UGuid	22	66	56	68	55	274
IR Cent Vens Implant Port Plcmnt US Guid	23	80	104	126	86	432
IR Central Venous Cath Revisn or Replcmt	10	14	15	16	9	65
IR Central Vens Cath Plcmt Tunnl US Guid	56	133	150	178	161	692
IR Cholangiogram T Tube Thru Ext Cath		2	1	6	8	17
IR Cholecystostomy	2	3	7	3	4	19
IR Conversion G to GJ Tube Perc		8	6	3	4	24
IR Convert Ext Biliary Dr to Int/Ext		1	1	1	1	4
IR Convert Nephrostomy to NU Stent Lt		3	1	3	1	9
IR Convert Nephrostomy to NU Stent Rt	1	4	2	1	1	9
IR D or J Tube Replacement Perc	4	21	16	12	12	67
IR Declot by Thrombo of Vascular Access		1		3	4	8
IR Dialysis Access Declotting Left	1				1	2
IR Dialysis Access Declotting Right	1					1

IR Drain Cath w/Guid Kid/Lvr/Spln		5	2		3	10
IR Drain Cath w/Guid Lung/Mediast		3	1	1		5
IR Drain Cath w/Guid Pancreas				2		2
IR Drain Cath w/Guid Perit/Retro	11	47	40	55	36	195
IR DUOD JEJ Tube Placement Perc			2	1		3
IR Embolization Extracranial			1			1
IR Esophageal Dilatation < 30mm		1		2	1	5
IR Feeding Tube Removal	1		4	7	3	15
IR Fistula Sinus Tract Study			1	2		3
IR Fistulagram Ndl/Cath Direct Punctr Lt	1	5	2	2	2	12
IR Fistulagram Ndl/Cath Direct Punctr Rt	3	1		1		5
IR Fistulagram/Declot/PTA Lt		1	1		1	4
IR Fistulagram/Declot/Stent Rt			1			1
IR Fistulagram/PTA Lt		4	5	2	3	15
IR Fistulagram/PTA Rt		3		1		4
IR FL Guid for Needl Plcmt Bx Asp or Inj		3		2	3	8
IR Fluoro Interventional up to 1 hour	4	7	9	9	9	39
IR G or C Tube Replacement Perc	2	10	15	10	12	51
IR G Tube Change Perc No Imag w/ tract				3	2	5
IR G Tube Change Perc No Imag w/o tract				18	21	41
IR GJ Tube Replacement Perc	11	15	25	20	25	96
IR Guided Pleural Drain/Chest Tube		12	9	11	4	37
IR Guided Thoracentesis			4	1		5
IR Injection Any GI Tube Perc		1	1	6	2	10
IR Insert Tunneled Cath Peritoneal	1	15	19	25	19	80
IR Insert Tunneled Cath Pleural	3	7	7	10	6	33
IR Insertion Stent Iliac INTL VSL			1			1
IR IVC Filter Plcmnt	5	5	3	2	6	22
IR IVC Filter Retrieval Remove		3	3	7	2	15
IR Lymphangiogram Extremity Left			1	1		2
IR Lymphangiogram Pelvic Abdominal				5	1	6
IR Mechanical Thrombectomy Venous					1	1
IR Mechanicl Thrombect NonCoronarArtrl			1		2	4
IR Neph Tube Removal with FL Guidance					2	2
IR Neph Tube Removal with FL Guidance t			3	1		4
R Neph Ureteral Stent NU Reml/Repl Bil				1	1	2
IR Neph Ureteral Stent NU Reml/Repl Lt		3	2	6	2	13
IR Neph Ureteral Stent NU Reml/Repl Rt		1	2	1	1	5
IR Nephrostogram Antegrade Lt		1		1		2
IR Nephrostogram Antegrade Rt	1	2				3
IR Nephrostogram Thru Existing Cath Lt			2		1	3
IR Nephrostogram Thru Existing Cath Rt		1		2	1	4
IR Nephrostomy Drainage Tube Change ft		15	19	19	10	63
IR Nephrostomy Drainage Tube Change Rt	2	5	4	7	5	23

IR Perc Abscess Drainage Cath Placement	1	2	2	1	3	9
IR Perc Biliary Access		1		3		4
IR Perc Biliary Cath Placement External		3	2	8		13
IR Perc Biliary Cath Plcmt Int and Ext	3	14	16	17	20	71
IR Perc Gastrostomy Tube Placement	12	25	35	34	51	161
IR Perc Nephro Ureteral Stent Plcmt Lt		1	1	1		3
IR Perc Nephro Ureteral Stent Plcmt Rt		1			3	4
IR Perc Nephrostogram Tube Placement Lt	1	13	15	11	9	49
IR Perc Nephrostogram Tube Placement Rt	2	11	5	12	10	40
IR Perc Transhepatic Cholangiogram			1	4	4	9
IR Perc Transhepatic Portagram w/o Hemo		1			1	2
IR Perc Transhepatic Portagram with Hemo	1	1		1	1	4
IR Perc Ureteral Stent Placement Left		1	2	2	2	7
IR Perc Ureteral StentPlacement Right		1	1			2
IR PICC w/ Imaging 5 yr and older				1	1	2
IR Pleural Cath W/Cuff Removal Tunneled	1	3	6	3	1	14
IR Sclerotherapy Fluid Collection		2	2	4		8
IR Sclerotherapy Single Right				1		1
IR Spinal Vertebroplasty	1	2				3
IR Spine Kyphoplasty AUG LumbaW/GUI		3	2	3	6	15
IR Spine Kyphoplasty AUG Thorac W/GUI		2	2	10	3	19
IR Spine Vrtbroplasty CervThor W/GUID		2	2	4		8
IR Spine Vrtbroplasty LumbSac W/GUID	1	1	2			4
IR Stent(s) Place Intravasc 1st Artery				1		2
IR Stent(s) Place Intravasc 1st Vein	1		1	1		3
IR Surgical Neph Access Plcmt New				1		1
IR Surgical Neph Access Plcmt Thru Exst				1		1
IR Thrombin Injection Extremity Right					1	1
IR Thrombolysis Art/Vein ea Addl Day			5	2		7
IR Thrombolysis Arterial Initial Day		4	5	5		14
IR Thrombolysis Cessation Cath Remove	1	2	4	3		10
IR Thrombolysis Venous Initial Day		2	2	1		5
IR TIPS Insertion	1	20	18	21	19	81
IR TIPS Revision		5	13	17	14	50
IR Tissue Ablation Ultrasound Guided		1		2		3
IR Transjugular Liver Biopsy US Guided	10	29	49	49	49	189
IR Tunneled Catheter Removal	17	111	149	165	134	588
IR Tunneled Port Removal	11	46	43	45	42	190
IR Ultrasound Abdomen in IR				2	1	3
IR Ultrasound Guided Needle Aspiration		8				8
IR Ultrasound Guided Needle Biopsy		3				3
IR Ureteral Stent Plcmt thru Exist Lt		4				4
IR Ureteral Stent Plcmt thru Exist Rt		2		1		3
IR Ureteral Stent/ Ileal Conduit Chg Lt	1	1	6	1	6	15

IR Ureteral Stent/ Ileal Conduit Chg Rt			1			1
IR Ureteral Stentogram and or Plcmt Lt		1			1	2
IR Ureteral Stentogram and or Plcmt Rt		1			1	3
IR US Guided Abdominal Paracentesis		1			1	2
IR US Guided Liver Biopsy Transplant				1		1
IR US Guided Needle Placement		2	3	1	1	8
IR Uterine Fibroid Embolization Complt	1	2	2	5	4	14
IR Vasc Embo w/Guid Hemrhg/Lymph rav	2	13	9	5	7	36
IR Vasc Embo w/Guid Tumor/Isch/Infarct	5	51	49	30	36	175
IR Vascular Embo w/Guid AVM/Aneur	1	7	7	4	2	21
IR Vascular Embo w/Guid Venous		5		2	1	9
IR Venogram Extremity Bilateral	1	1	1	2	1	6
IR Venogram Extremity Left		1		1	1	3
IR Venogram Extremity Right	1	1		2	1	5
IR Venogram Hepatic with Hemodynamics	1	12	3	5	2	23
IR Venogram Hepatic wut Hemodynamics	1	2	1			4
IR Venogram Inferior Vena Cava IVC	2	3	5		1	12
IR Venogram Renal Left			1			1
IR Venogram Superior Vena Cava SVC	2			1	3	6
IR Venous Pressure Measurement		14	4	1		19
IR Venous Sampling		12	12	5	2	31
Totals	**298**	**1101**	**1198**	**1348**	**1158**	**5212**