



# Impact of incidental findings in preoperative CTA imaging for autologous breast reconstruction

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## KEYWORDS

Breast reconstruction;  
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**Abstract** *Background:* CT angiography (CTA) can be performed pre-operatively for perforator mapping in autologous breast reconstruction. The full impact of incidental CTA findings on breast reconstruction remains unclear.

*Methods:* CTAs were reviewed for all patients who underwent imaging prior to autologous breast reconstruction at Yale New Haven Hospital from 2013–2018. CTA findings and all resulting follow-up imaging, treatment, and change in management were catalogued. Our findings were compared to other published reports in the literature to better categorize the impact of CTA findings on patient care.

*Results:* Records from 341 patients were reviewed. One hundred fifty-four patients (45.2%) had incidental findings with 15.6% requiring further imaging or biopsy. Three patients (0.9%) underwent a change in management. One patient was diagnosed with metastatic disease prior to mastectomy. Another two patients required gynecologic procedures as a result of the CTA findings. Data was pooled with three other series in the literature for aggregate analysis of 959 operative planning CTAs. In total, incidental findings were present in 53.7% of patients. In the meta-analysis, 10.4% of patients required additional imaging or biopsy and 1.4% of screening CTAs impacted medical management.

*Conclusion:* Pre-operative autologous breast reconstruction planning reveals incidental findings in approximately half of all imaging studies. In an analysis of nearly 1000 CTAs, patient care was impacted in 1.4% of cases. If imaging is obtained for planning purposes, the

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reconstructive microsurgeon should carefully review the full imaging report given its potential impact on patient care.

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## Introduction

Operative techniques in microvascular breast reconstruction have been steadily refined since the first free transverse rectus abdominus myocutaneous (TRAM) flap described by Holmstrom in 1979.<sup>1</sup> As surgeons have sought to minimize donor site morbidity, the reconstructive paradigm has evolved to the muscle-sparing TRAM (MS-TRAM) and most recently perforator flaps such as the deep inferior epigastric perforator (DIEP) flap.<sup>2-8</sup>

Paralleling advancements in microsurgical flap design, CT angiography (CTA) has found increasing acceptance as a preoperative planning tool to map the precise location and caliber of perforating vessels for flap harvest. Application of CTA varies across centers. While some centers use CTAs selectively in patients with prior abdominal surgery, other centers routinely order CTAs for all cases and, still, some centers never use them. Microsurgeons in favor of CTA see value from the imaging and report faster intra-operative decision making, shorter operative times, and lower complication rates.<sup>9-12</sup>

Prior studies of CTA incidental findings during autologous flap planning have had small sample sizes with a wide range of incidental findings reported from 13% to 76%.<sup>13-15</sup> While these “incidentalomas” typically are benign, others require additional imaging, biopsy, specialist referral, or surgery. Because CTA imaging is most often ordered and reviewed by the microsurgeon, following-up on the proper referral and potential management of these incidental findings rests with the plastic surgeon.

The chief aim of this study was to review our institutional experience with pre-operative CTA imaging and develop a more accurate understanding of the impact of incidental finding from a data-analysis incorporating our findings with the available literature.

## Patients and methods

Following institutional review board approval, patients who underwent delayed or immediate microvascular breast reconstruction from 2013 to 2018 were identified retrospectively at Yale New Haven Medical Center. Patients who underwent a pre-operative CTA of the abdomen or pelvis for the purposes of operative planning prior to perforator flap breast reconstruction were included.

Operative reports, radiographic imaging reports, and medical chart records were reviewed. Incidental findings were classified by organ system. Subgroup analysis was performed between patients with normal CTA and those with incidental findings and compared cancer stage, cancer type, pre- and post-operative chemotherapy, and pre- and post-operative radiation. Categorical variables were compared

**Table 1** Indications for Pre-operative CTA Prior to Microvascular Autologous Breast Reconstruction.

	n (%)
Patients	341 (100)
DIEP	291 (85.3)
MS-TRAM	33 (9.7)
PAP	2 (0.6)
SGAP	5 (1.5)
SIEA	3 (0.9)
Multi	6 (1.8)

DIEP, Deep Inferior Epigastric Perforator; MS-TRAM, Muscle Sparing Transverse Rectus Abdominus Muscle; SIEA, Superior Inferior Epigastric Artery; PAP, Profunda Artery Perforator; SGAP, Superior Gluteal Artery Perforator.

using chi-squared analysis. Statistical significance was considered when  $p < 0.05$ .

After reviewing our institutional experience, an aggregate data analysis was performed to evaluate the composite data from the literature. Eligible papers were identified using keywords “Breast Reconstruction, Incidental Finding, CT Angiogram, Microvascular Breast Reconstruction, and DIEP.”

One report in the literature reported the number of “radiographically suspicious” lesions with the most common additional investigation suggested by the radiologist but did not report whether the recommended work-up was pursued and was therefore omitted from the “incidental findings which required further diagnostic evaluation” portion of the pooled data-analysis.<sup>14</sup> While two of the four studies included incidental findings of chest and neck CTA, planning CTA performed at our institution only included the abdomen and pelvis.<sup>13,15</sup> Organ system classifications which were not applicable to our findings were reported with N/A.

## Results

Four hundred ninety-seven patients underwent autologous breast reconstruction during the study period with 341 meeting inclusion criteria. The majority of microvascular reconstructions were DIEP flaps (85.3%) followed by MS-TRAM flaps (9.7%). The remainder of flap categories included superior gluteal artery perforator (SGAP) flaps (1.5%), superficial inferior epigastric artery (SIEA) flaps (0.9%), profunda artery perforator (PAP) flaps (0.6%), or multiple free flaps (1.8%), (Table 1).

Incidental findings were identified in 154 patients (45.2%). Incidental findings were classified by organ system (Table 2) and were most prevalent in the genitourinary tract. The 69 GU incidental findings included ovarian cysts, uterine fibroids, and ovarian varices. The second most

**Table 2** Incidental findings by organ system for all studies included in the pooled data-analysis.

Author	Hughes	Ho	See	Tong	Gabrick	Total
Year	2016	2016	2008	2012	2018	
# Patients	154	360	104	69	341	1028
Incidental Findings (I.F.)	117 (76%)	231 (64.2%)	13 (12.5%)	25 (36%)	154 (45.2%)	514 (50.7%)
I.F. + Further Investigation	32 (20.8%)	N/R	7 (6.7%)	4 (5.8%)	24 (15.6%)	67 (6.5%)
I.F. -> Change Mngt	8 (5.2%)	0	2 (1.9%)	1 (1.4%)	3 (0.9%)	14 (1.4%)
Thyroid (Cysts, Goiter)	2	0	0	0	N/A	2
Pulmonary (Nodules, Granuloma, Radiation Changes)	23	27	0	5	N/A	55
Lymph Nodes	11	7	0	1	5	24
Breast (Cysts)	1	0	0	0	N/A	1
GI Tract (Hiatal Hernias Diverticula)	5	0	0	2	32	39
Endocrine (Adrenal, Pancreas)	0	28	1	1	1	31
Hepatobiliary (Cysts, Fatty Infiltrate, cirrhosis, Gall stones)	35	108	7	6	22	178
Spleen (Cysts)	1	10	1	3	1	16
Renal (Cysts, Calculi, Scarring)	10	47	2	3	20	82
Pelvic (Ovarian Cysts, Fibroids, Varices)	7	63	1	5	69	145
Bony Abnormalities (Sclerotic lesions, Osteoradionecrosis)	8	55	0	3	5*	66
Soft Tissue (Post-Radiation Changes)	3	0	0	2	0	5
Vascular	0	1	0	0	12	13
Misc. (Neurofibromas, foreign bodies)	3	87	0	1	6	97

I.F., Incidental Finding; Mngt, Management; N/R, Not Recorded; N/A, Not Applicable;

\* Exclusion Criteria Differs From Other Studies.

**Table 3** Types of additional diagnostic evaluations following suspicious CTA findings.

Study	n = 25
CT	7
MRI	2
Ultrasound	15
Biopsy	1

common organ system was the GI tract with 32 findings, mostly hernias and diverticula. Twenty findings were also identified in the renal system (cysts, calculi, and scarring), and 22 findings in the hepatobiliary system (cysts, cirrhosis, gallstones, and fatty infiltrate). The remaining organ systems represented a small minority of incidental findings and included: vascular (12 findings), miscellaneous neurofibromas and foreign bodies (6 findings), bone (5 findings), endocrine (1 finding), and spleen (1 finding), (Table 2).

Twenty-four patients (15.6% of CTAs with incidental findings) required further evaluation with 25 studies: 15 ultrasounds, 7 CT scans, 2 MRIs, and 1 biopsy, (Table 3). Three incidental findings (0.9% of CTA) changed surgical management. One patient with Stage IIB invasive ductal carcinoma was found to have metastatic hepatic disease on CTA canceling her planned surgery. Another patient with ductal carcinoma in situ was found to have a cystic mass in her right ovary. She underwent bilateral laparoscopic salpingo-oophorectomy for resection of the cystic ovary concurrently with the second stage of breast reconstruction. The third patient had Stage III invasive ductal

carcinoma and underwent bilateral salpingo-oophorectomy and a suspicious pelvic mass was resected at the time of breast reconstruction. The remaining incidental findings did not require further evaluation nor did they impact surgical management.

When comparing patients with an unremarkable CTA to those with incidental findings, there were no significant differences between the cohorts (Table 4). Breast cancer stage, breast cancer type, adjuvant radiation or chemotherapy rates, neoadjuvant chemotherapy rate, or history of prior chest irradiation were not significantly different.

Four other papers evaluating incidental findings of pre-operative CTA were identified in the literature. Hughes et al. described 154 patients and found 117 (76% of CTA) had incidental findings.<sup>13</sup> Thirty-two (20.8% of CTA) required additional diagnostic evaluation and eight scans (5.2% of CTA) changed management. Change in management was due to the discovery of previously undetected metastatic disease in 6 patients. Two other patients cancelled reconstruction over ultimately benign findings (suspicious lymph node and diagnosis of sarcoidosis). (Table 5)

Ho et al. published a series of 360 planning CTAs with 231 (64.2% of CTA) incidental findings.<sup>14</sup> The number of incidental findings requiring work-up was not recorded, but they reported no patients with change in management. (Table 2)

Tong et al. published their experience with 69 patients with 25 incidental findings (36% of CTA). Four patients (5.8%) required additional studies for evaluation, and care was impacted in one case (1.4%) after the discovery of metastatic disease.<sup>16</sup> (Table 2)

**Table 4** Change in management following incidental findings.

Study	# Change in Mgmt per study / finding	Impact on care
Gabrick, 2018	3 Liver Metastasis Ovarian Mass Bilateral Adnexal Mass	Reconstruction Canceled Bilateral Salpingoophrectomy Bilateral Salpingoophrectomy and resection of pelvic mass
Ho, 2016	0	
Hughes, 2016	8 Suspicious Internal Mammary Node Metastatic (Breast Primary) Metastatic Melanoma Bone Metastasis Sarcoidosis Distant Metastasis Metastatic Disease	Patient Declined Reconstruction Patient Died Patient Died Patient Declined Reconstruction Patient Declined Reconstruction Chemotherapy Under Follow Up
Tong,	1 Distant Metastasis	Canceled Reconstruction
See, 2008	2 Angiomyolipoma Uterine Dermoid Cyst	Nephrectomy Subsequent Diagnosis of Metastatic Disease

Mgmt., Management.

**Table 5** Subgroup analysis comparing those with incidental findings to those with normal CTA scans.

	Normal scan	Incidental finding	p Value
Patients	187	154	
History of Prior Radiation	17 (11.4%)	23 (12.6%)	0.747
Adjuvant Radiation	29 (19.5%)	36 (19.7%)	0.962
Neoadjuvant Chemotherapy	40 (26.8%)	52 (28.4%)	0.715
Adjuvant Chemotherapy	38 (25.5%)	54 (29.5%)	0.417
Stage			0.686
	0	15 (4.9%)	
	1	39 (12.8%)	
	2	28 (9.2%)	
	3	20 (6.6%)	
	4	2 (0.7%)	
	Prophylactic	61 (36.5%)	
Cancer Type	DCIS	27 (15.9%)	0.454
	Invasive Ductal	57 (33.5%)	
	LCIS	6 (3.5%)	
	Invasive	13 (7.6%)	
	Lobular		
	Mixed	1 (0.6%)	
	Inflammatory	2 (1.2%)	

DCIS, Ductal Carcinoma In Situ; LCIS, Lobular Carcinoma In Situ.

Finally, See et al. published a series of 104 patients with 13 incidental findings (12.5% of CTA) of which 7 patients (6.7%) required additional studies and 2 patients (1.9%) had a change in management.<sup>15</sup> One patient was found to have a renal mass necessitating nephrectomy and delaying breast reconstruction. The second patient was found to have a uterine mass determined to be metastatic disease. A complete summary of incidental findings which changed management is shown in (Table 2).

Composite results from the pooled data-analysis included 1028 patients who underwent planning CTA. A total of 514

patients (50.7%; Range: 12.5-76.0%) were found to have incidental findings. Additional diagnostic evaluation was necessary in 67 patients (6.5%; Range: 6.7-20.8%), and 14 patients (1.4%; Range: 0.9-5.2%) had a change in management, (Table 6).

## Discussion

This study retrospectively reviewed our multi-year institutional experience with planning CTA prior to autologous

**Table 6** Aggregate results from pooled data analysis.

	Total
# Patients	1028
Incidental Findings (I.F.)	514 (50.7%)
I.F. + Further Investigation	67 (6.5%)
I.F. - > Change Mgmt	14 (1.4%)

I.F., Incidental Finding; Mgmt, Management; N/R, Not Recorded.

microvascular breast reconstruction. A pooled data-analysis incorporating our results with the published literature was used to determine a more accurate and powered assessment of the risk of critical incidental findings. Incidental findings following planning CTA were found in slightly over half of scans with one in 10 requiring additional work-up. While rare, one in 100 pre-operative CTAs have incidental findings that impact patient health and management.

Of the most significant incidental findings, identifying previously undetected metastatic disease was present in 0.6% of CTAs.<sup>13-16</sup> While these events are exceedingly rare it demonstrates the importance of having the plastic surgeon review the CTA results in their entirety, as opposed to solely reviewing perforators, and following through with effective communication to the surgical and medical oncology teams.

The second most important incidental findings were ones requiring operative intervention. Of the fourteen incidental findings which impacted management, three required operative intervention. See et al. reported a case of angiomyolipoma which required nephrectomy prior to breast reconstruction.<sup>15</sup> Two patients in our series were found to have suspicious masses found on planning CTA which required surgical resection. The first patient was found to have an ovarian mass which was resected during a laparoscopic bilateral salpingo-oophorectomy performed concurrently with the second stage of her breast reconstruction. Another patient in our series was found to have an adnexal mass on CTA and underwent bilateral salpingo-oophorectomy and mass excision at the time of microvascular breast reconstruction. Numerous reports in the surgical literature support the safety and efficacy of combined procedures in gynecology and plastic surgery.<sup>17-19</sup> Identifying this pelvic mass enabled a combined surgical procedure and a single recovery period for two patients.

Patients with a diagnosis of stage IIIA breast cancer routinely undergo CT or MRI imaging with optional FDG PET/CT.<sup>20,21</sup> Current guidelines for invasive breast cancer management do not recommend CT or MRI in clinical stage I-IIB except in the context of relevant laboratory or clinical findings. Imaging findings of previously undetected metastases in low clinical stage remains rare, consistent with our study findings.<sup>22-24</sup> Metastatic disease identified on screening CTA occurs in patients who do not otherwise meet criteria for routine CT or MRI imaging.

Limitations of the study include its retrospective nature and the heterogeneous patient populations. The pooled data-analysis represents the highest power description to date regarding the impact of incidental findings.

## Conclusion

In conclusion, the application of planning CTA has demonstrated utility allowing for faster intra-operative decision making, shorter operative times, and lower complication rates. Incidental findings are common and found in 50.7% of CTA. However, in 1.4% of planning scans incidental findings may impact patient care including cancelation of reconstruction, cancer upstaging, and extra surgical procedures by other surgical specialties.

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## Conflict of interest

None.

IRB approval was obtained.

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