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Incidental Findings in CT and MR Angiography for Preoperative Planning in DIEP Flap Breast Reconstruction

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Background: Autologous breast reconstruction with deep inferior epigastric perforator flaps is considered a standard of care in the treatment after mastectomy, yet vascular anatomy is highly variable and perforator selection remains challenging. The use of preoperative imaging can influence surgical planning and assist intraoperative decision-making. However, this imaging can inevitably uncover incidental findings. The purpose of this study was to analyze incidental findings, evaluate correlation with patient factors, and examine effects on overall care.
Methods: A retrospective review was performed on 350 consecutive patients who received magnetic resonance angiography (MRA) or computed tomographic angiography (CTA) as a preoperative evaluation for deep inferior epigastric perforator flap breast reconstructions done between August 2015 and June 2019. Radiology reports were analyzed for incidental findings. Patient charts were reviewed for patient history, genetic history, cancer treatment, and type of reconstruction.
Results: Of the 350 patients meeting the criteria, 56.9% were noted to have incidental findings on preoperative imaging, 12.9% received additional imaging, and 4.0% underwent additional interventions. There was no difference in the percentage of patients with incidental findings between immediate and delayed reconstructions or between CTA and MRA. Five patients were found to have malignancies.
Conclusions: Preoperative CTA and MRA is a valuable tool to optimize outcomes and efficiency in breast reconstruction with abdominal perforator flaps. However, this imaging can also be beneficial to the overall wellness of the patient. With the high prevalence of incidental findings on preoperative imaging, it is important to counsel patients and adjust surgical plans, if necessary. *(Plast Reconstr Surg Glob Open 2020;8:e3159; doi: 10.1097/GOX.0000000000003159; Published online 23 October 2020.)*

INTRODUCTION

The deep inferior epigastric perforator flap (DIEP) is now considered a standard of care in autologous-based breast reconstructions. As abdominal-based breast reconstruction evolved from the transverse rectus abdominus myocutaneous flap to the DIEP flap, there was added difficulty in perforator dissection and longer operative times for the more technically demanding surgery. Although DIEP flaps are now routinely performed, the vascular anatomy of the deep inferior epigastric vessels is highly variable and perforator selection remains challenging.[1,2] Doppler ultrasound was initially employed as a preoperative imaging modality to help surgeons overcome these challenges. However, ultrasound is operator-dependent, time-consuming, and lacks the anatomic details of other imaging modalities.[3,4] Computed tomographic angiography (CTA) was introduced as an alternative preoperative imaging technique, which provided a high spatial resolution with accurate imaging of the perforators in a format that was easier for the operating surgeon to review. CTA has been shown to accurately depict perforator location, caliber, and course with a close correlation to intraoperative findings.[5–9]

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Initially CTA was mainly used in patients with prior abdominal surgeries, gynecological surgeries, or liposuction. Through its use, preoperative imaging has been shown to influence surgical planning, decrease operative time, and assist in intraoperative decision-making.[1,10–12] Now, many surgeons routinely use CTA or magnetic resonance angiography (MRA) on every planned case of abdominal perforator flap breast reconstruction.

However, as with any form of diagnostic imaging, preoperative CTA or MRA can inevitably uncover incidental findings. In the trauma and emergency department literature, incidental findings have been reported in 33%–51% of patients undergoing CT scans.[13–15] In previous studies on CTA for DIEP flap planning, the prevalence of incidental findings ranged from 13% to 75%. However, no studies have compared incidental findings in CTA and MRA or investigated these findings in the context of timing of reconstruction. The purpose of this study is to analyze the incidental findings discovered on preoperative imaging for DIEP flap breast reconstruction, evaluate the effects on overall care, and examine correlation with patient factors.

METHODS

Chart Review

We performed a retrospective review of all patients seen in consultation for breast reconstruction by 2 surgeons at our institution over a 4-year period (August 2015–June 2019). Patients who underwent preoperative MRA or CTA of the abdomen and pelvis in planning for DIEP flap breast reconstruction met the criteria for inclusion in the study. Patients who underwent DIEP flap reconstruction but did not receive a CTA or MRA were excluded from this study.

Radiology reports were individually evaluated, and incidental findings were extracted. The findings were categorized by systems: respiratory, cardiac, endocrine, gastrointestinal, urinary, reproductive, lymphatic, musculoskeletal, or vascular. Findings were further stratified as confirmed or not confirmed. Because of the varied terminology used by radiologists, confirmed findings were defined by the following phrases: most compatible with, most consistent with, statistically, likely, and probably. Recommendations for further imaging were also recorded and reviewed. If this imaging was performed and confirmed the incidental finding, then this finding was placed in the confirmed category. If the finding could not be defined or distinguished, it was placed in the not confirmed category.

The electronic medical record was reviewed for each patient and demographic information was extracted, including age at time of imaging, body mass index, history of other cancers, family history of breast cancer, and genetic predisposition. Furthermore, type of breast cancer and indication for mastectomy were recorded. The reconstruction was categorized as unilateral or bilateral. It was further categorized as immediate, delayed, or immediate and delayed. In patients with incidental findings, any additional work-up (including imaging and interventions) was followed and it was documented if breast reconstruction was delayed or canceled.

Imaging Protocol

In all patients undergoing CTA for preoperative imaging, 100 cc of contrast was injected at a rate of 3–4 ml/s followed by a 15-second delay. Contrast-enhanced images were performed from the thoracic inlet through the ischial tuberosity in an inspiratory state, a gantry rotation time of 0.6 seconds, and a pitch factor of 0.984 at 120 kV. Images were reconstructed in the coronal and axial planes with 1.5-mm spacing and 1.5-mm-thick slices, and in the sagittal plane with 5-mm spacing and 10-mm-thick slices. The aorta was always included at the highest levels through the femoral arteries to include all vascular abdominal structures and deep inferior epigastric vessels.

In patients undergoing MRA for preoperating imaging, all clothing was removed and the patient was positioned on a body array or phased array coil. The field was set to a similar range as above. Axial and coronal T2-weighted single shot fast spin echo images were first obtained. Axial liver accelerated volume acquisition (LAVA) was then performed with 125 kHz bandwidth, 512 × 512 matrix, 3-mm-thick slices reconstructed at 1.5-mm intervals using a 2-fold zero interpolation, and a scan time of at least 4 minutes. Subsequently, 20 ml of gadobenate contrast medium was injected at 1ml/sec, starting simultaneously with the scan followed by a 20-ml normal saline flush. LAVA-flex was then performed to account for any issues with fat suppression. Finally, a breath hold coronal and sagittal LAVA was obtained to examine for metastasis.

Statistical Analysis

Mean, range, and SD were utilized to describe continuous and normally distributed variables. Percentages were used to describe our population. Univariate analyses with categorical variables were performed using chi-square and Fisher exact tests to determine differences in the prevalence of incidental findings by timing of reconstruction, genetic predisposition, and the type of preoperative image performed. Significance was determined at a *P* value of less than 0.05. All statistical analyses were performed using IBM SPSS software (IBM SPSS Statistics for Windows, Version 25.0. Armonk, N.Y.: IBM Corp).

RESULTS

Demographics

During the study period, 350 patients (602 breasts) were included for the analysis. The mean age at the time of imaging was 49.9 years (range: 27–75 y). A total of 320 patients (91.4%) received CTA and 30 patients (8.6%) received MRA for preoperative planning purposes. 95.4% (334 cases) of patients underwent a deep inferior epigastric perforator flap reconstruction, and 4.6% (16 patients) of patients did not undergo the originally scheduled reconstruction at our institution. The majority of cases were bilateral breast reconstructions (69.8%, 244 cases) and the remaining 94 cases (26.8%) were unilateral reconstructions. With regard to timing of reconstruction, 40.0% (140 patients) underwent a delayed

breast reconstruction, 38.6% (135 patients) underwent an immediate reconstruction, and 16.3% (57 patients) underwent an immediate and delayed breast reconstruction (Table 1).

The most common type of cancer diagnosed was invasive ductal carcinoma (33.2%), followed by ductal carcinoma in situ (7.8%), and then invasive lobular carcinoma (5.1%). Prophylactic mastectomies were performed in 231 breasts (38.4%) (Table 1).

Table 1. Patient Demographics and Reconstruction Characteristics

Characteristics		Patients
No. patients		350
No. breasts		602
Mean age at imaging, range, ± SD, years		49.9 (27–75) ± 9.7
Mean BMI, range, ± SD, kg/m2		28.5 (18–48) ± 5.6
Type of imaging performed (%)		
	CTA	320 (91.4)
	MRA	30 (8.6)
Breast cancer type (%)*		
	Invasive (infiltrating) ductal carcinoma	200 (33.2)
	Ductal carcinoma in situ	47 (7.8)
	Invasive (infiltrating) lobular carcinoma	31 (5.1)
	Lobular carcinoma in situ	8 (1.3)
	Undifferentiated	1 (0.2)
	Malignant phyllodes	1 (0.2)
	Other	6 (1.0)
	No cancer	231 (38.4)
	Information not available	77 (12.8)
Genetic predisposition (%)		
	BRCA+	43 (12.3)
	BRCA–	119 (34.0)
	Other mutation	12 (3.4)
	Genetic study not performed	176 (50.3)
Family history of breast cancer (%)		139 (39.7)
Breast reconstruction (%)		
	DIEP flap	334 (95.4)
	Implants	4 (1.2)
	Not performed†	12 (3.4)
Breast reconstruction laterality (%)		
	Bilateral	244 (69.8)
	Unilateral	94 (26.8)
	Not performed to date†	12 (3.4)
Prophylactic mastectomy (%)*		231 (38.4)
Breast reconstruction timing (%)		
	Delayed	140 (40.0)
	Immediate	135 (38.6)
	Immediate + delayed	57 (16.3)
	Not reconstructed	12 (3.4)
	Information not available	6 (1.7)

*In number of breasts (n = 602).
†Not performed due to being lost to follow-up, not a candidate for DIEP reconstruction after imaging, patient preferences or incidental findings on imaging.
BMI, body mass index.

Incidental Findings by Timing of Reconstruction

A total of 293 incidental findings were found in 199 patients (56.9% of our population). Of these findings, 83.3% (244 findings) were confirmed in 182 patients and 16.7% (49 findings) were categorized as not confirmed in 27 patients (Table 2). When comparing the prevalence of incidental findings by the timing of reconstruction, the highest percentage of incidental findings were found in patients who underwent a delayed breast reconstruction (59.3%), followed by patients who underwent an immediate and delayed breast reconstruction (54.4%), and then those who underwent an immediate breast reconstruction (54.1%). However, no significant differences were found between these groups ($P = 0.649$) (Table 2).

Incidental Findings by Genetic Predisposition

A total of 174 patients met the criteria and underwent testing to assess genetic predisposition to breast cancer. Of all patients, 43 patients (12.3%) were found to be BRCA positive and 119 (34.0%) were BRCA negative. A different genetic mutation included in the testing panel was found in 12 patients (3.4%) (Table 1). This panel included the CHECK2, BARD1, ATM, MUTYH, CDH1, RAD51C, and PALB2 mutations. There was no statistically significant correlation between incidental findings on preoperative imaging and genetic predisposition to breast cancer ($P = 0.203$). An estimated 46.5% of patients with a BRCA positive mutation were found to have an incidental finding, whereas 55.5% of BRCA negative patients had an incidental finding. In the other mutations group, 75% of patients were found to have an incidental finding (Table 2).

Incidental Findings by Imaging

As mentioned above, an incidental finding was found in 199 patients. In 40.0% of patients (140 patients), incidental findings were confirmed by the initial CTA or MRA imaging. In 22.6% of cases (79 patients), additional imaging was recommended to better evaluate inconclusive findings. Additional imaging was conducted in 45 of those patients, and an intervention, most commonly an image-guided biopsy, was performed in 14 patients. When analyzing the type of preoperative image performed, there was a higher percentage of incidental findings found in patients who underwent MRA compared with CTA (63.3% vs. 56.3%). However, no statistically significant difference was found between these two groups ($P = 0.454$) (Table 3).

Categorization of Incidental Findings

Of the total 244 confirmed incidental findings, 41.4% (101 findings) were categorized to the gastrointestinal system. Hepatic cysts, umbilical hernias, and hiatal hernias were the most common findings in this system. The reproductive system had the next most frequent findings, with 20.5% (50 findings). Uterine fibroids and ovarian cysts were the most common within this system. The urinary system had 14.3% (35 findings) of incidental findings, and renal cysts were the most common within this group. Findings were least common in the cardiovascular and lymphatic systems, with 1.6% and 0.4% of the total of incidentalomas, respectively (Table 4).

Table 2. Incidental Findings and Patient Factors

Characteristics				Patients
Patients with incidental findings (%)*				199 (56.9)
Patients with confirmed findings (%)*				182 (52.0)
Incidental findings (%)†	Total incidental findings			293
	Confirmed			244 (83.3)
	Not confirmed			49 (16.7)
Incidental findings by timing of reconstruction				
	Immediate	Delayed	Immediate + Delayed	*P*
Patients with incidental findings (%)	73 (54.1)	83 (59.3)	31 (54.4)	0.649
Incidental findings by genetic predisposition				
	BRCA positive	BRCA negative	Other mutations	*P*
Patients with incidental findings (%)	20 (46.5)	66 (55.5)	9 (75.0)	0.203

*Percentage based on number of total patients.
†Percentage based on the total number of patients with incidental findings.

Table 3. Incidental Findings and Imaging

Characteristics			Patients
Initial imaging (%)*	Patients with incidental findings		199 (56.9)
	Patients with findings confirmed by initial imaging		140 (40.0)
Additional imaging (%)*	Patients asked for additional imaging		79 (22.6)
	Patients with additional imaging performed		45 (12.9)
	Patients with findings confirmed by additional imaging		42 (12.0)
Additional intervention*	Patients undergoing additional interventions		14 (4.0)
Patients with incidental findings by type of imaging (%)			
	CTA	MRA	*P*
Patients with incidental findings (%)	180 (56.3)	19 (63.3)	0.454

*Percentage based on number total patients.

Malignancy

Importantly, 5 cases of malignancy were diagnosed based on an incidental finding discovered in the preoperative CTA, MRA, or in subsequent imaging. Two patients were diagnosed with pancreatic adenocarcinoma, 2 patients with breast cancer metastasis to liver and bone, and 1 patient with large B-cell lymphoma. All of these patients underwent CTA imaging.

In 4 of these patients, the DIEP flap reconstruction was canceled or delayed until after completion of oncologic treatment. All of these patients required additional imaging to confirm the initial findings (Table 5).

DISCUSSION

Preoperative CTA and MRA is a valuable tool to optimize outcomes and efficiency in autologous breast reconstruction; however, additional information other than perforator anatomy is often included with the radiology reports. We sought to better understand the prevalence of incidental findings in these imaging studies, how to manage them, and how they correlate with patient factors. The overall rate of incidental findings was 56.9%, with 293 findings in 199 of the 350 patients imaged. An estimated 83.3% of these findings were confirmed by initial or follow-up imaging. The most common findings were categorized into the gastrointestinal, reproductive, and urinary systems.

In our study, 12.9% of patients with incidental findings proceeded to get additional imaging and 4.0% underwent additional interventions most commonly image-guided biopsy. Of these patients, 5 were ultimately diagnosed with breast cancer metastasis or a new malignancy. It could be argued that additional interventions as a result of preoperative imaging could delay the initial ablative procedure. However, in these patients, the imaging resulted in earlier detection and influenced the course of their treatment. A preoperative CTA could be considered an additional staging imaging test when the chest, abdomen, and pelvis are all included. Although we found no statistically significant difference between incidental findings in delayed and immediate reconstruction patients, CTA could be particularly beneficial in those patients with a significant gap in time between initial staging and reconstruction. It is notable that all 5 patients diagnosed with metastasis or a new malignancy were patients undergoing delayed reconstruction.

Of the 350 patients undergoing preoperative imaging, reconstruction was not performed at our institution in 12 patients. These patients were either lost to follow-up, not a candidate for DIEP flap reconstruction after imaging, changed their reconstructive preferences, or had a concerning incidental findings on their imaging requiring additional workup. Interestingly, 1 patient who was planning on undergoing bilateral mastectomies with a DIEP flap reconstruction was found to lack a deep inferior epigastric system unilaterally and an atrophic rectus muscle. This patient had a history of numerous abdominal and pelvic surgeries, including cholecystectomy, hysterectomy, oophorectomy, and bariatric surgery. This case highlighted the importance of vascular imaging in this patient population and reinforced our institution's support of the preoperative imaging protocol.

Table 4. Categorization of Confirmed Incidental Findings

System	Subcategories	Count (%)
Respiratory	Lung nodules	14
	Lung cysts	1
	Lung granulomas	1
	Radiation pneumonitis	1
	Tracheal diverticulum	1
	Total respiratory	18 (7.4)
Cardiac	Pericardial effusion	3
	Pericardial cysts	1
	Total cardiac	4 (1.6)
Endocrine	Adrenal adenoma	6
	Thyroid nodules	5
	Thyroid hyperplasia	2
	Thyroid adenoma	1
	Adrenal cysts	1
	Total endocrine	15 (6.1)
Gastrointestinal	Hepatic cysts	38
	Hiatal hernia	17
	Hepatic hemangioma	5
	Hepatic focal nodular hyperplasia	4
	Bochdalek hernia	3
	Splenic cysts	2
	Pancreatic adenocarcinoma	2
	Peritoneal nodule	2
	Pancreatic lipoma	1
	Biloma	1
	Biliary hamartoma	1
	Intussusception	1
	Periumbilical hernia	5
	Umbilical hernia	19
	Total gastrointestinal	101 (41.4)
Urinary	Renal cysts	26
	Renal calculi	6
	Renal angiomyolipoma	1
	Ureteral calculi	1
	Urinary bladder cysts	1
	Total urinary	35 (14.3)
Reproductive	Uterine fibroids	20
	Ovarian cysts	15
	Adnexal cysts (not specified)	9
	Breast nodules	3
	Ovarian teratoma	2
	Uterine adenomyosis	1
	Total reproductive	50 (20.5)
Lymphatic	Large B-cell lymphoma	1
	Total lymphatic	1 (0.4)
Musculoskeletal	Enostosis (bone island)	11
	Inguinal hernia	1
	Femoral hernia	1
	Bone lytic lesions	1
	Vertebral metastases	1
	Total musculoskeletal	15 (6.1)
Vascular	Renal fibromuscular dysplasia	1
	Renal artery aneurysm	1
	Celiac artery aneurism	1
	Splenic artery aneurysm	1
	Abdominal aortic ulcer	1
	Total vascular	5 (2.0)
Total confirmed incidental findings		244

The percentage of patients with incidental findings in this study was within the range previously reported in the literature: 13%–75%.[4,16–18] Ho et al[16] published a review of 360 patients undergoing preoperative CTA imaging, with 64% of patients discovered to have incidental findings. When looking at patient factors, this study found that the presence of CTA incidentalomas was associated with the presence of comorbidities but was not correlated to BRCA status, breast cancer stage, or cancer recurrence.[16] When we examined patient factors in our study, we also did not find a statistically significant correlation between incidental findings on preoperative imaging and genetic predisposition to breast cancer. Additionally, there was no significant correlation between timing of reconstruction and rate of incidental findings.

Hughes et al[17] published a report on 154 consecutive patients undergoing CTA for preoperative planning for DIEP flap reconstruction and discovered incidental findings in 75% of patients. When examining how these findings changed management, they reported that in 24% of patients the findings prompted additional investigation and in 5% of patients the operative plan was altered by the findings. Occult metastasis was discovered in 6 of these patients after subsequent imaging.[17]

Two additional studies reported on incidental findings in preoperative CTA by See et al[18] and Tong et al.[4] Prevalences of findings were lower in these reports: 13% and 36%, respectively.[4,18] However, in these studies, only the abdomen and pelvis were imaged, whereas in our study the thorax was also imaged. Numerous variables could affect the difference in these reported rates of incidental findings. The type of scanner used, the thickness of the axial slices, and the field of imaging used for the CTA protocol could all influence detection. In addition, the threshold for reporting incidental findings is different for each institution and even between radiologists at the same institution. Furthermore, a patient population with a history of a known malignancy could also affect the threshold for reporting a suspicious finding. Interestingly in our study, there was no significant difference in incidental findings between CTA and MRA imaging.

The American College of Radiology published a 4-part series on managing incidental findings on abdominal and pelvic CT and MRI and more recently on managing incidental findings on thoracic CT. These papers provide

Table 5. Patients with a Diagnosis of a New Malignancy

Patient	Initial Imaging Diagnosis	Additional Imaging Requested?	Additional Treatment	Confirmed Diagnosis	Reconstruction Delayed?
1	CTA: Marked pancreatic duct dilatation	Yes	Distal pancreatectomy and splenectomy, chemo, XRT	Pancreatic adenocarcinoma	Yes
2	CTA: Possible metastatic disease of the liver	Yes (CT)	US-guided biopsy, chemo	Hepatic metastasis	Yes
3	CTA: Possible vertebral metastases	Yes (PET CT)	CT-guided biopsy, hormonal therapy	Vertebral metastases	No
4	CTA: Thoracic paravertebral lesion highly suspicious of metastatic disease	Yes (MRI, PET CT)	CT-guided biopsy, chemo, radiation	Large B-cell lymphoma	Yes
5	CTA: Indeterminate low-attenuation pancreatic tail lesion	Yes (MRI)	FNA, distal pancreatectomy and splenectomy, chemo	Pancreatic adenocarcinoma	Yes

MRI, magnetic resonance imaging; PET, positron emission tomography; XRT, radiotherapy.

general recommendations and guidance on management in patients asymptomatic for the designated finding and without prior imaging.[19–23] Although each patient's history is different, these recommendations could be useful for the reconstructive surgeon to be familiar with when determining the next steps after an incidental finding is detected.

With the high rate of incidental findings, it is important for the reconstructive surgeon to prepare patients for the possibility of these findings before preoperative imaging. It is also important for the reconstructive surgeon to be prepared to disclose these findings to patients. A delicate but thorough disclosure is necessary to keep the patient fully informed but try to minimize any additional anxiety in a patient population that has already received a life changing diagnosis. To help facilitate this process, referral processes should be put in place to expedite additional testing or imaging, if recommended.

CONCLUSIONS

CTA imaging for preoperative planning for DIEP flap reconstruction has shown to be beneficial not only to facilitating reconstruction but also potentially to the overall health of the patient in identifying malignancies and harmful findings earlier in their clinical course. It is important for the reconstructive surgeon to counsel patients on the possibility of incidental findings preoperatively, have the appropriate referral lines in place to expedite additional testing, and be prepared to adjust surgical plans, if necessary.

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