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Breast

Preoperative Computed Tomography Angiography in Autologous Breast Reconstruction—Incidence and Impact of Incidentalomas

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Background: Incidentalomas are lesions found coincidentally during examination, imaging, or surgical procedures. Preoperative computed tomography angiography (CTA) before abdominal flap harvest for breast reconstruction can lead to identification of incidentalomas leading to the need for further investigations. The aim of this study was to examine the prevalence of incidental findings on preoperative CTA and to determine their impact on management.

Methods: A retrospective chart review was performed at a single tertiary institution. CTA reports were analyzed for the presence of incidental findings and details of follow-up were studied. Logistic regression was used to identify factors associated with incidental findings.

Results: One hundred eighteen patients with a mean age of 49 years were included in the study. The majority of patients underwent bilateral reconstruction (65%, n = 77) in the immediate setting (70%, n = 83). Fifty-six percentage had an incidental finding on CTA, with hepatic (20%), renal (14%), and osseous (11%) abnormalities being most common. Additional imaging including ultrasound, CT, and magnetic resonance imaging were recommended in 19 cases (16%). Additional consultations were sought for 3 patients before reconstruction (with suspicion of bone metastases, an intraabdominal mass, and suspicion of colonic malignancy, respectively). No significant surgical delay secondary to CT findings was noted.

Conclusions: Incidentalomas following preoperative CTA of the abdomen/pelvis are common (56%). However, unlike previous reports, we did not observe a change in reconstructive plan following incidentaloma discovery. We recommend that all patients are counseled pre-CTA regarding the possibilities of incidentaloma detection and need for additional imaging. *(Plast Reconstr Surg Glob Open 2018;6:e2019; doi: 10.1097/GOX.0000000000002019; Published online 12 December 2018.)*

INTRODUCTION

The advent of perforator flaps offers women greater reconstructive choice and an opportunity to minimize donor-site morbidity. Allen and Treece[1] popularized the deep inferior epigastric perforator (DIEP) flap for the purpose of autologous breast reconstruction. The main theoretical advantage of the DIEP compared with the transverse rectus abdominis musculocutaneous flap is that it can provide a natural looking reconstruction while preserving fascia and muscle, therefore reducing the functional impact on the abdominal wall and postoperative pain.[1–3] DIEP flaps have gained considerable popularity and have become the standard of care for autologous breast reconstruction in suitable patients.[4] DIEP flaps are, however, more technically demanding and potentially time consuming, requiring careful intramuscular dissection of the perforating vessels.[1] Success of reconstruction depends upon accurate assessment of highly variable abdominal wall perforator anatomy for flap design and harvest. This challenge has resulted in some advocating the routine use of CT angiography (CTA) to optimize preoperative planning, improve surgeon confidence and operative speed, and shorten duration of anesthesia.[5,6]

The advantages of preoperative CTA imaging are well supported but one must also consider its associated disadvantages. CTAs require additional radiation, hospital

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visits, healthcare costs, and a potential delay of surgery.[4] In practice, preoperative CTA leads to identification of incidental findings resulting in further clinical queries, examinations, and investigations in a patient population already under duress. Incidental findings are defined as masses or lesions found by coincidence during physical examination, imaging procedure, or surgical procedures. Lumbreras et al.[7–9] have stratified incidental findings into 3 categories: category 1—major clinical relevance with findings that might alter the patient's clinical course; category 2—moderate relevance with findings where follow-up is sufficient; and category 3—minor clinical relevance with findings not influencing the patient's course.

There is a paucity of studies examining the incidence of incidentalomas in breast reconstruction and more specifically on the clinical sequelae of the incidental findings. Reported rates of incidentalomas vary from 36% to 64% of patients who undergo preoperative CTA. Importantly, incidental findings have been reported to change the reconstructive plan in 5% of cases.[10] The aim of this study was to examine the incidence of incidental findings in patients undergoing CTA for preoperative planning at our institution in order so that we can ensure the appropriate structures are in place when incidental findings are reported and to best counsel our patients by setting realistic patient expectations.

METHODS

Institutional review board approval was obtained before conducting the study. Consecutive patients of 2 microsurgeons (D.N. and A.M.) at a tertiary institution were included for review if they underwent a CTA before free abdominal tissue transfer for breast reconstruction during the study period from March 2013 to February 2018. Patients were identified using STARR, the Stanford Medicine Research Data Suppository. All data were collected onto a secure database.

Baseline patient demographics were collected, including age, comorbidities (including smoking, diabetes, previous nonbreast cancer), previous abdominal/pelvic surgery, the presence of a genetic mutation on genetic testing, and breast cancer stage. CTA reports were reviewed and the reports were analyzed for the presence of incidental findings, in addition to date of acquisition, dose of radiation, and contrast required. The anatomical location, suspected diagnosis, and required follow-up imaging or investigation of an incidental finding were recorded. If further imaging was requested, the modality was noted. The time from CTA to reconstructive surgery was examined to determine if CTA findings, specifically incidental findings, led to a delay to reconstruction. In addition, medical notes were reviewed to determine sequelae after CTA imaging: the need for further specialist consultation or additional treatment required.

The standard CTA planning for patients undergoing DIEP flap reconstructions at Stanford Hospital and Clinics follows a standard protocol. If a patient wishes to proceed with abdominal free tissue transfer, the rationale for CTA imaging is explained to the patient in the clinic and consent is obtained to proceed with scheduling.

Statistical Analysis

All statistical analyses were performed on SPSS (version 24.0, Chicago, Ill.). A P value < 0.05 was considered statistically significant. Continuous data were described with means and SDs of the mean when parametric, and with medians and ranges when nonparametric. Data were reported as frequencies when categorical. The Pearson's chi-square test was used to assess association between categorical variables.

The Fisher's exact test was used when frequencies were <5. Independent samples t test (two-tailed) was used to compare quantitative varies between 2 groups when parametric, and the Wilcoxon-Mann-Whitney was used for nonparametric data.

Multivariable logistic regression analyses were performed to determine factors predictive of incidental findings. Factors significant at $P = 0.25$ in univariable analyses were entered into multivariable analyses. Regressions were repeated excluding partial amputations for sensitivity analyses.

RESULTS

We identified 137 patients who had undergone CTA before planned breast reconstruction using the STARR database (Fig. 1). Nineteen patients identified using the database were excluded from the study due to insufficient records. We therefore retrospectively reviewed the clinical data of 118 patients (Fig. 2).

Demographic details are described in Table 1. The mean age at the time of CTA was 49.8 years (SD, 9.88 years; median, 47.5 years) and the vast majority of patients underwent therapeutic mastectomy before reconstruction [therapeutic n = 104 (88%), prophylactic n = 14 (12%)]. Over two-thirds of our patients had bilateral reconstruction (n = 77, 65%), whereas the majority of our patient cohort underwent breast reconstruction in the immediate setting (n = 83, 70%). CTA imaging was associated with a mean radiation dose of 1,097.6 ± 446 mGy/cm, and patients received a mean of 108.3 ± 26.5 ml of contrast material. Regarding the stage of breast cancer, the majority of patients had stage 2 breast cancer (42.1%, n = 48). We noted that 32 patients (28.0 %) who underwent genetic testing had clinically significant genetic mutations (BRCA1 n = 16, BRCA2 n = 9, MUYTH n = 3, tP53 n = 1, CHEK2 n = 1, CDH n = 1 and Ashkenazi founder mutation n = 1), whereas 7 patients (5.9%) had mutant variations of uncertain significance. Thirteen patients (1.1%) had a history

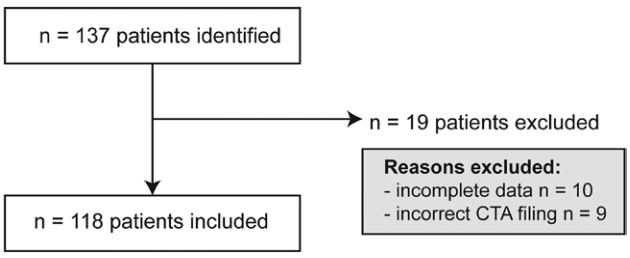

Fig. 1. A flow diagram showing the patients identified and included in the study.

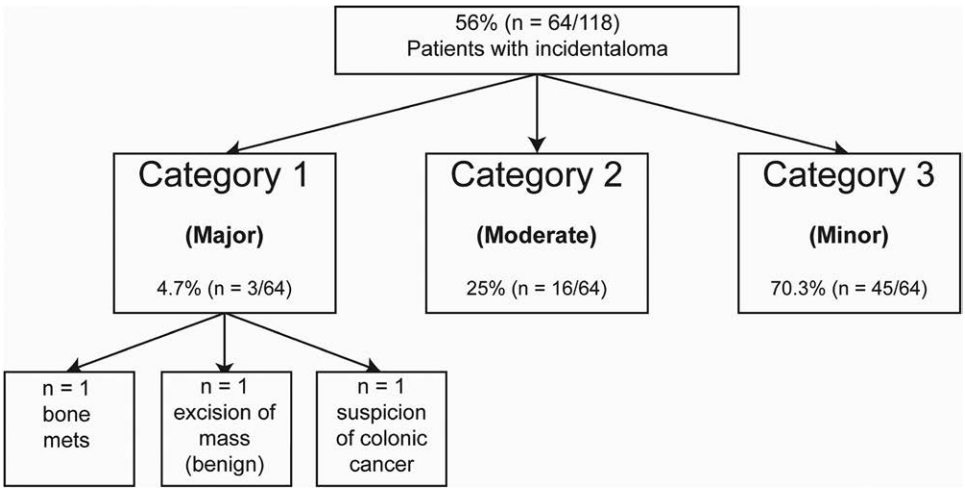

Fig. 2. Clinical significance of CTA findings.

Table 1. Patient Demographic, Operative, and Admission Details

Mean Age at CTA (y; ± SD)	**49.8 (±9.88)**	
Indication for breast surgery, n (%)	Therapeutic: 104 (88.1)	Prophylactic: 14 (11.9)
Bilateral or unilateral recon, n (%)	Unilateral: 41 (34.7)	Bilateral: 77 (65.35)
Timing of reconstruction (d), n (%)	Immediate: 83 (70.3)	Delayed: 35 (29.7)
Breast cancer stage*, n (%)	Stage 0: 25 (21.9)	
	Stage I: 20 (17.5)	
	Stage II: 48 (42.1)	
	Stage III: 14 (12.3)	
	Stage IV: 7 (6.1)	
Genetic mutation, n (%)	Yes: 39 (33.1)	Not tested: 43 (36.4)
	BRCA1: 16 (13.6)	
	BRCA2: 9 (7.6)	
	Other: 14 (11.9)	
Previous cancer, n (%)	50 (42.4)	
Previous nonbreast cancer*, n (%)	13 (11.1)	
Diabetes*, n (%)	1 (0.8)	
Smoker*, n (%)	1 (0.8)	

*% Reported out of a total n = 118, except for: breast cancer stage (n = 114); diabetes (n = 116); previous nonbreast cancer, smoker, previous nonbreast cancer (all n = 117).

Table 2. CTA Findings

Radiation Dose (mGy/cm, Mean ± SD)	**1,098 (±442)**
Contrast dose* (ml, mean ± SD)	108.8 (±26.5)
Abnormal findings, n (%)	Liver: 23 (19.5)
	Kidney: 17 (14.4)
	Bone: 13 (11.0)
	Vasculature: 13 (11.0)
	Adnexal anatomy: 11 (9.3)
	Hernia: 7 (5.9)
	Pancreas: 3 (2.5)
	Other: 16 (13.6)
Previous abdominal surgery, n (%)	59 (50)
	Appendectomy: 5 (4.2)
	Cholecystectomy: 6 (5.1)
	Pelvic: 47 (39.8)
	Liposuction: I (0.8)
	Ventral open hernia repair: 1 (0.8)
	Inguinal open hernia repair 2 (1.7)
	Robotic nephrectomy: 1 (0.8)

*% Reported out of a total n = 118, except for: total contrast dose (n = 116).

of prior nonbreast cancer, whereas 43 (36.4%) patients had a previous diagnosis of breast cancer.

Sixty (50.8%) patients had underwent previous surgery; pelvic/gynecological surgery in 47 patients (39.8%), open appendectomy (n = 5, 4.2%), open cholecystectomy (n = 6, 5.1%), abdominal liposuction (n = 1), open hernia repair (inguinal n = 2, ventral n = 1), and robotic nephrectomy (n = 1; Table 2).

Incidental findings were identified in 56% of patients (n = 64). The most common sites were liver (n = 23, 20%), kidney (n = 17, 14%), and bone (n = 13, 11%). Of note, 18 patients (15%) had more than 1 incidental finding (Fig. 2).

The vast majority of incidental findings required no further investigations (category 3—minor clinical relevance with findings not influencing the patient's course; Table 2, Fig. 2). Additional imaging was requested in 19 patients with ultrasound (n = 7) being most prevalent, CT (n = 5), magnetic resonance imaging (MRI) (n = 5), and colonoscopy (n = 1) being less commonly requested. The mean time to the follow-up imaging study was 3 months. Contrast studies were specifically requested in all CT and MRI imaging tests requested. The 3 patients with category 1 clinically significant incidentaloma all went on to have breast reconstruction but did require additional physician review. The 3 patients with category 1 findings had (1) new diagnosis of bone metastases in a patient with delayed reconstruction who underwent free flap reconstruction to address chronic pain; (2) an intraabdominal mass that went on to be resected at the time of the reconstructive surgery with the final path showing a benign lesion; and (3) concern for colonic malignancy.

Table 3. The Association of Demographic Information and Delay from CTA to Surgery with Incidence of Incidental CTA Finding in 118 Patients*

Characteristics	Incidental Finding (n = 64)	%	No Finding (n = 54)	%	*P*
Prophylactic surgery					
Yes	6	42.9	8	57.1	
No	58	56.3	45	43.7	0.343
Delayed surgery					
Yes	22	62.9	13	37.1	
No	42	50.6	41	49.4	0.222
Breast cancer stage					
0	14	56	11	44	
I	9	45	11	55	
II	29	60.4	19	39.6	
III	7	50	7	50	
IV	3	42.9	4	57.1	0.750
Genetic mutation					
Yes	15	38.5	24	61.5	
No	20	55.6	16	44.4	
NT	29	67.4	14	32.6	0.031
Previous nonbreast cancer					
Yes	9	69.2	4	30.8	
No	55	52.9	49	47.1	0.264
Previous breast cancer					
Yes	30	69.8	13	30.2	
No	34	45.3	41	54.7	0.010
Previous surgery					
Yes	33	55	27	45	
No	31	53.4	27	46.6	0.506
Smoker					
Yes	1	100	0	0	
No	63	54.3	53	45.7	0.547
Delay to breast surgery					
Yes	1	100	0	0	
No	63	53.8	54	46.2	0.542

*Chi-squared was used for all statistical comparisons except where frequencies were <5, in which case Fisher's exact test was used. All statistical comparisons n = 118, except for missing data for: prophylactic surgery, previous nonbreast cancer surgery, smoking (all n = 117), and breast cancer stage (n = 117).

The mean time from CTA to reconstructive surgery was 6±6 weeks. No patient was explicitly noted to experience a delay to breast surgery from findings detected on CTA in medical reports. Additionally, there was no significant time difference to surgery in patients who had an incidental finding reported compared with those who did not [5.58±6.33 weeks versus 7.4±6.5 weeks, t = -1.543 (two-tailed), $P = 0.126$].

Patients in whom incidentalomas were reported were significantly older than those patients in whom no incidentalomas were reported (51.4±10.0 years *versus* 46.6±9.1 years, t = 2.680, $P = 0.008$). There was no significant effect of genetic mutation (either BRCA1, BRCA2, or other genetic mutations) on having an incidental finding reported on the presurgical CTA ($P = 0.031$; Table 3). Additionally, patients who did not have a previous diagnosis of breast cancer were less likely to have an incidentaloma reported at the CTA in both univariable [34/75 (45.3%) versus 30/43 (69.8%), $P = 0.010$; Table 3] and multivariable analysis (odds ratio, 0.383; 95% confidence interval, 0.165–0.888; $P = 0.025$; Table 4).

DISCUSSION

Incidentalomas in otherwise asymptomatic women inevitably prompt further anxiety, investigations, and cost. The study aim was to define the incidentaloma detection rate in order so that we can best prepare our patients' expectations before proceeding with a relatively "routine" preoperative investigation in the setting of free flap reconstruction in our institution.

The incidentaloma rate in our patient cohort was 56%. This rate is at the higher end of the ranges reported in the literature, which have varied from 36%[10] to 64%.[11]

Comparative assessment of incidentaloma rates between studies, however, is difficult, given the variations in cohorts and CT interpretation protocols between different institutions. It may not be surprising that our results indicate a relatively high incidence of incidentalomas, given that we are a tertiary center with a prominent surgical oncology practice, and which therefore may be associated with hypervigilance for detecting and investigating potential malignancies across all members of staff.

The most common sites were liver, kidney, and bone with 15% of patients having more than 1 incidental finding, corroborating observations by Ho et al.[11] Importantly, only 2 findings were clinically significant, supporting the previous observation that relatively few incidentalomas are clinically significant. Despite the low risk of malignancies, 19 additional tests were required to ascertain this diagnosis. Investigations following incidentalomas can amount to considerable healthcare costs.

Additional testing may be associated with considerable patient anxiety as one must disclose the findings from the imaging studies and propose further investigation/management plans. Furthermore, reports are increasingly available directly to patients, leading to possibility for independent patient interpretation and further anxiety before disclosure by the surgical team. Despite a high incidence of incidentalomas, the reconstructive plan remained largely unchanged, unlike a previous study that reported a 5% change in reconstructive plan following incidentaloma discovery.[11]

In this study, the radiology reports did not consistently state clear recommendations for interpretation of incidental findings, which thus generated clinical uncer-

Table 4. Analysis of Factors Associated with Report of an Incidental Finding at the Preoperative CTA Using a Multivariate Logistic Regression Analysis in N = 118 Patients

Factor	*P*	OR	95% CI	Reference Group
Delayed surgery	0.201	0.570	0.741–4.156	Delayed
Genetic mutation: no	0.663	0.726	0.274–1.927	Not tested
Genetic mutation: yes	0.033	0.347	0.135–0.890	Not tested
No previous breast cancer	0.025	0.383	0.165–0.888	Previous breast cancer

CI, confidence interval; OR, odds ratio.

tainty. Indeed, at least 2 patients themselves requested a subspecialty surgical review to discuss findings reported on CTA. The most appropriate management for incidental findings on abdominal CT is an area of uncertainty, and to resolve the variability in management, the American College of Radiology incidental finding committee published a series of papers providing on their recommendations on the management of incidentalomas reported on abdominal and pelvic CT and MRI.[12–16] Based on these recommendations, we recommend that all patients are counseled pre-CTA regarding the benefits in terms of preoperative planning, but also the possibilities of incidentaloma detection and its incidence, and a need for additional imaging.

Although CTAs are the most common preoperative imaging modality in DIEP planning, alternative imaging strategies have been proposed. Magnetic resonance angiography (MRA) is being offered as an alternative at several centers, reducing radiation exposure. CT and MRA are both accurate in identifying deep inferior epigastric artery (DIEA) perforator branches and are equivalent in demonstrating perforator-venous connections.[17] Additionally, CTAs require ionized contrast media, which have disadvantages over the gadolinium-based contrast agents employed in MRAs.[17] In addition, Sergesketter et al. recently found that preexisting CT scans also can represent a viable and economical alternative for perforator mapping before abdominal-based free flap breast reconstruction,[18] thus reducing the rate of additional incidental findings on subsequent CTA.

Delay in breast reconstruction following incidentaloma discovery is a concern in patients with potentially active breast cancer. A delay in breast oncological surgery is associated with increased mortality.[19] In this report, however, there was no significant difference in time interval to surgery between patients in whom an incidentaloma was reported and those with a normal CTA report.

The limitations of this study include its retrospective nature, reporting on the outcomes of 2 surgeons (D.N. and A.M.) at a single tertiary center. Additionally, being a tertiary center, there may be an emphasis on "cancer treatment" at the surgical center, biasing the CTA reporting to be hypervigilant.

Future work may consider a qualitative assessment of patient experience to study the subjective anxiety experienced in relation to CTA testing, hearing the CTA findings, and the follow-up investigations recommended upon reports of incidentalomas.

CONCLUSIONS

Incidentalomas in otherwise asymptomatic women inevitably prompt further anxiety, investigations, and cost. Here, we report an incidentaloma rate of 56%. However, while we note a high rate of incidentaloma detection, we did not find that there was a significant change in reconstructive plan following incidentaloma discovery. Our study supports the previous observation from general imaging reports that relatively few incidentalomas constitute clinically significant conditions. Going forward, we recommend that all patients are counseled of the possibilities of incidentaloma detection and need for additional imaging following CTA.

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