^{18}F-Fluorodeoxyglucose Positron Emission Tomography/Computed Tomography in Postsurgical Setting in Head and Neck Cancers – A Pictorial Essay

Abstract

This pictorial essay depicts normal appearances, complications, and findings of residual and/or recurrent disease on fluorodeoxyglucose positron emission tomography/computed tomography (18F-FDG PET/CT) studies in the postsurgical setting. Reading and reporting 18F- FDG PET/CT in the postoperative scenario is demanding due to the multiple false positives seen during this period. This article which contains two parts will familiarize the readers with the normal appearance and pitfalls seen in 18F- FDG PET/CT studies during the postoperative period so as to avoid misinterpretations. This pictorial will discuss 18F- FDG PET/CT in the postoperative scenario in head and neck cancers.

Keywords: *Contrast-enhanced, false-positives, fluorodeoxyglucose positron emission tomography/computed tomography, postoperative, postsurgical, pitfalls, recurrence*

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Introduction

Fluorodeoxyglucose positron emission tomography/computed tomography (18F-FDG PET/CT) has established itself as a very effective imaging modality in the past two decades. It forms the mainstay of oncology practice and is routinely used for the staging and restaging of multiple cancers. Reading 18F- FDG PET/CT in posttreatment setting remains a challenging task, due to treatment-related changes and inflammation. This becomes even more difficult in the postoperative setting due to distortion of the normal anatomical structures, loss of symmetry, and due to the inflammation and fibrosis seen after surgery. FDG uptake is seen in inflammation and postoperative complications such as infection, abscess, fistula, and fat necrosis. [Table 1]; these have confounding features, which at times makes it difficult to differentiate these from recurrent disease. The process of wound healing itself shows increased FDG uptake due to the accumulation of inflammatory cells, fibroblasts, and macrophages in the granulation tissue. This granulation tissue is gradually removed by apoptotic cells, followed by the formation of a mature scar. The FDG uptake gradually decreases from the formation of granulation tissue to the development of a mature scar. These processes make take about 2–3 months to occur.[1-3] In the postoperative period, it is important to differentiate recurrent disease from normal physiological uptake and postoperative complications.

This pictorial review is aimed at familiarizing its readers and nuclear medicine physicians with these scenarios so as to help in the reading of 18F- FDG PET/CT studies in this setting. Being well versed with the normal appearance and complications arising in the postoperative setting will assist us in confidently reporting these studies. Some steps taken before doing an 18F- FDG PET/CT will aid in reducing the false-positive FDG uptakes in this period [Table 2].

Learning objectives

1. Familiarly with normal postsurgical appearances
2. Normal physiological findings which are mimics for disease involvement
3. Methods to differentiate between recurrent disease and postsurgical appearances and complications
4. Importance of doing a contrast-enhanced CT (CECT) with PET/CT.

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Case Scenarios

The imaging findings in the postoperative setting in head and neck can be divided into three scenarios:

1. Altered anatomy – due to reconstructive procedures, with the formation of surgical voids and flaps
2. Postoperative complications – infections, inflammation, abscess, fistula, collections
3. Disease per se or recurrent disease

Normal appearance postsurgery in head and neck cancers

Multimodality treatment comprising of curative surgical resection combined with radiation therapy and or chemotherapy is generally needed for locally advanced head and neck cancers, in particular in sinonasal and oral cavity malignancies. Curative resection may consist of wide local excision or complex reconstructive surgeries to close the defect, leading to large surgical voids and anatomical distortion. The void may show no FDG uptake [Figure 1] or mild, diffuse uptake around the void, which is physiological. When a large part of tumor is removed along with a part of the mandible to achieve adequate tumor-resection margins, it is repaired using flaps. This may involve placement of either a simple flap made of one tissue type or a composite flap-like pedicle flap or free flap; having two or more tissue types. Pectoralis major

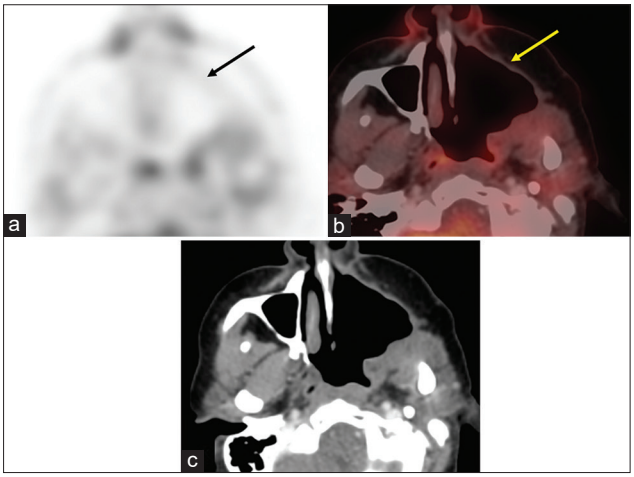

Figure 1: Normal appearance of a postsurgical void. A 50-year-old lady, who had undergone left maxillectomy for an ameloblastoma. fluorodeoxyglucose positron emission tomography/computed tomography was done 7 months after the surgery. Fluorodeoxyglucose positron emission tomography/computed tomography scan shows a surgical void in the left maxillary region with no fluorodeoxyglucose uptake in the axial positron emission tomography and fused positron emission tomography/computed tomography images (arrow a and b)

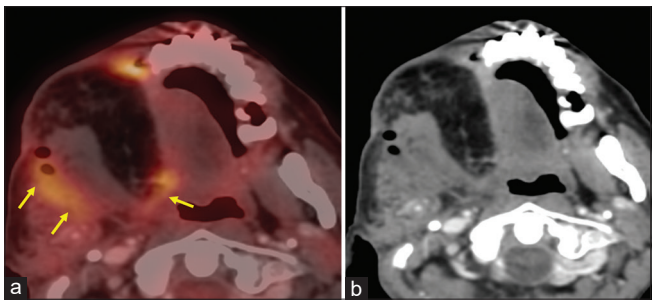

Figure 3: Normal appearance (mild, diffuse uptake) of a postsurgical flap. A 58-year-old gentleman, squamous cell carcinoma of the right buccal mucosa. He had undergone right hemi-mandibulectomy with pectoralis major myocutaneous flap and nodal dissection. Fluorodeoxyglucose positron emission tomography/contrast-enhanced computed tomography was done 6 weeks after surgery. The axial fused positron emission tomography/computed tomography images show mild, diffuse, heterogenous fluorodeoxyglucose uptake at the flap-site (arrows in a), postright hemimandibulectomy. This appearance of diffuse fluorodeoxyglucose uptake around the flap is reactive and often seen postsurgery

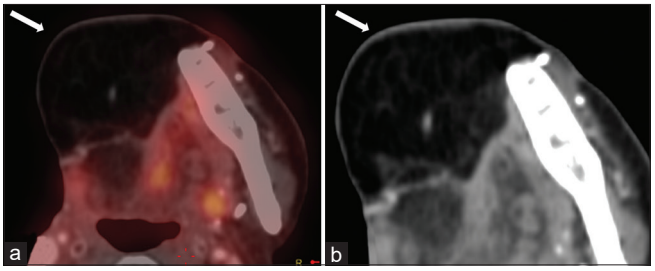

Figure 2: Normal appearance (no fluorodeoxyglucose uptake) of a postsurgical flap. A 60-year-old gentleman, squamous cell carcinoma of the right lower alveolus. Underwent right hemi-mandibulectomy with pectoralis major myocutaneous flap. Fluorodeoxyglucose positron emission tomography/contrast-enhanced computed tomography was done 12 weeks after surgery. The axial fused positron emission tomography/computed tomography and computed tomography images show the pectoralis major myocutaneous flap with no increased fluorodeoxyglucose uptake (arrow in a and b). The flap is a fat-density structure having sharp boundaries with adjacent structures. CECT image in b, showing no enhancing soft tissue mass.

Figure 4: Normal appearance of a postsurgical donor-flap site. The same patient as in case 3. A 58-year-old gentleman, squamous cell carcinoma of the right buccal mucosa. He had undergone right hemimandibulectomy with pectoralis major myocutaneous flap and nodal dissection. Fluorodeoxyglucose positron emission tomography/contrast-enhanced computed tomography was done 6 weeks after surgery. The maximum intensity projection and the fused coronal positron emission tomography/computed tomography images show linear, diffuse fluorodeoxyglucose uptake in the right sternal and axillary area (arrow in a, b). This is due to reactive changes at the donor flap site. Note the absence of pectoralis major on the right (arrowhead in c) in the fused axial positron emission tomography/computed tomography image. The right pectoralis major is the donor for the pectoralis major myocutaneous flap reconstructive surgery done for this patient

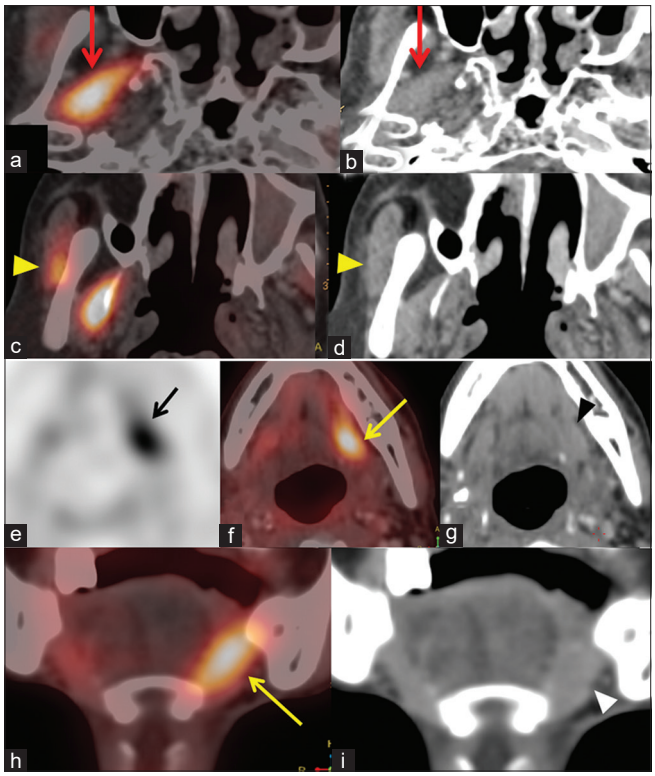

Figure 5: (a) Physiological uptake in muscles of the head and neck, postsurgery. A 65-year-old gentleman, post right hemimandibulectomy for squamous cell carcinoma of the right buccal mucosa. Fluorodeoxyglucose positron emission tomography/contrast-enhanced computed tomography was done 3 years after surgery. Axial fused positron emission tomography/computed tomography image shows diffuse increased fluorodeoxyglucose uptake in the right lateral pterygoid muscle (arrow in a) and in right masseter muscle (arrowhead in c). Note the absence of any enhancing mass lesion in the contrast-enhanced computed tomography images in both the muscles (arrow in b and arrowhead in d). Physiological uptake in muscles of the head and neck, postsurgery. A 67-year-old gentleman, squamous cell carcinoma of the right buccal mucosa. Underwent right composite resection with forehead flap. Fluorodeoxyglucose positron emission tomography/contrast-enhanced computed tomography was done 6 months after the surgery. Axial positron emission tomography and fused axial and coronal positron emission tomography/computed tomography images show increased fluorodeoxyglucose uptake in hypertrophied left mylohyoid muscle (arrow in e, f and h). Note the absence of any enhancing mass lesion in the contrast-enhanced computed tomography images (arrowhead in g and i)

myocutaneous flap (PMMC) is an example of a composite, pedicle flap, donor muscle being pectoralis major. The appearance of a flap is a fat density structure with sharp boundaries with adjacent structures. Immediately after the surgery, a myocutaneous flap has muscle/soft-tissue attenuation which gradually undergoes denervation atrophy leading to volume loss and fatty replacement within the flap [2-9]. Postsurgical 18F- FDG PET/CT imaging of these flaps done 8–12 weeks after surgery may demonstrate no FDG uptake [Figure 2] or mild diffuse uptake around the periphery of the flap [Figure 3]. Mild, diffuse FDG uptake around the flap is reactive and often seen in the postoperative period. Apart from the site of the reconstructive surgery, even the donor site of the PMMC flap may show diffuse FDG uptake [Figure 4], these are

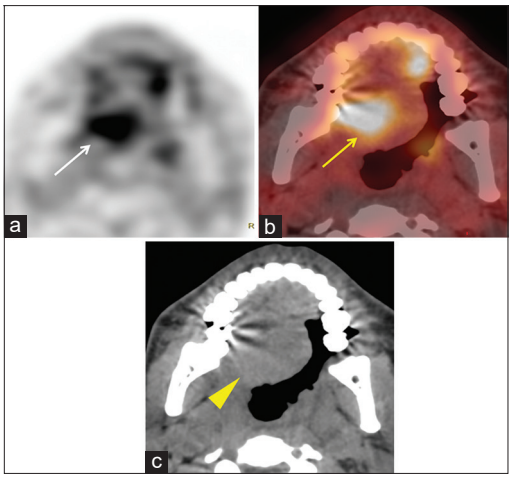

Figure 6: Physiological uptake in the remnant tongue. 58-year-old gentleman, squamous cell carcinoma of left lateral border of the tongue. Underwent left hemiglossectomy. Fluorodeoxyglucose positron emission tomography/contrast-enhanced computed tomography was done 16 weeks after the surgery. Intense, focal fluorodeoxyglucose uptake is noted in the axial positron emission tomography and fused positron emission tomography/computed tomography images in the right side of the remnant tongue (arrow in a, b). This can easily be mistaken for disease involvement. Note that there is no mass or enhancing mass lesion in the axial contrast-enhanced computed tomography image (arrowhead in c)

Table 1: Pitfalls in postsurgical scenario

Process of wound healing
Infections
Inflammation
Collections
Abscesses
Fistulas
Hematoma
Flap necrosis
Fat necrosis
Asymmetric physiological uptakes, especially in muscles of the head and neck

Table 2: Suggested methods to avoid the pitfalls in the postsurgical setting

FDG PET/CT to be done 8-12 weeks after the surgery to allow for wound healing
Performing a contrast-enhanced CT along with PET/CT
Detailed history and knowledge of the type of surgery/procedure done
Knowledge of potential complications occurring during this period
Familiarity with the PET/CT appearances of postsurgical changes and complications

FDG: Fluorodeoxyglucose, PET: Positron emission tomography, CT: Computed tomography

reactive inflammatory changes seen for a few weeks after surgery and should not be mistaken for disease.[2,3]

Due to removal of the muscles on the diseased side or due to distortion of normal anatomical structures, a unilateral

muscle may show diffuse increased FDG uptake leading to asymmetrical muscle uptake on FDG PT/CT study. This occurs due to altered mechanics of mastication or altered muscle usage often seen post head, neck, and jaw surgeries. This typically appears as FDG uptake along the entire length of the muscle with no enhancing mass lesion[Figure 5].[2,4]

Such asymmetric uptake is also quite common after partial tongue resection. Physiological uptake in the remnant tongue may appear as focal, intensely FDG avid area, which is a potential mimic for residual or recurrent disease. Reviewing the CECT images carefully helps us to differentiate between the two.[2,4] Absence of contrast-enhancing mass lesion is indicative of remnant structure, in this case, remnant tongue and not malignant disease process [Figure 6].

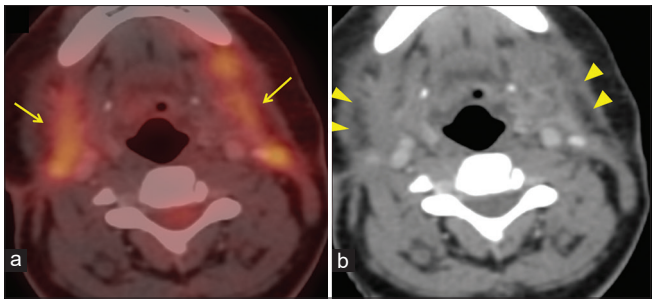

Figure 7: Postoperative inflammation. 56-year-old gentleman, squamous cell carcinoma of right lateral border of the tongue. Underwent wide excision of the tongue mass. Had recurrence and bilateral nodal metastases, 7 months after the first surgery. Underwent bilateral nodal dissection. Fluorodeoxyglucose positron emission tomography/contrast-enhanced computed tomography was done 5 weeks post neck dissection, before starting adjuvant treatment. Diffuse, linear fluorodeoxyglucose uptake is noted in both sides of the neck in the fused axial positron emission tomography/computed tomography (arrows in a). Note the fat stranding on the computed tomography images (arrowheads in b), due to postoperative inflammation

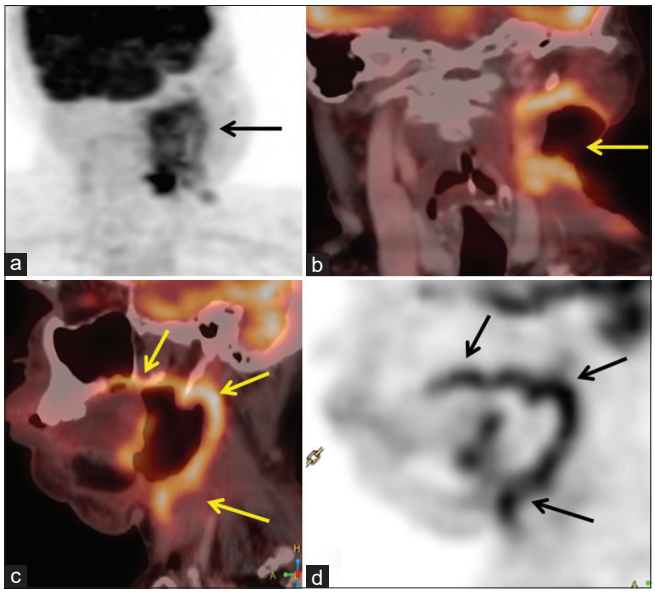

Figure 9: Orocutaneous fistula at the flap site. 55-year-old gentleman, squamous cell carcinoma of the left retromolar triangle, underwent bite composite resection with pectoralis major myocutaneous flap and neck dissection. 6 months after the surgery, the patient presented with purulent discharge from the left submandibular region. The maximum intensity projection image shows diffuse intense fluorodeoxyglucose uptake in the left side of the face (arrow in a). The fused coronal image shows a fistula opening in the left submandibular region (arrow in b). The fused sagittal positron emission tomography/computed tomography and PET images (arrows in c, d) show the path of the sinus tract, extending from the left maxilla along the left infratemporal fossa and opening in the left submandibular region

Complications, post head, and neck surgery

Complications due to infection and inflammation are common false-positive findings after head and neck surgeries. These could be due to postoperative inflammation of the surrounding tissues [Figure 7], particularly when the 18F-FDG PET/CT scan is done too early in the postoperative period to start the adjuvant chemotherapy or radiotherapy. This is usually diffuse and subsides with time.[5,7,8] Infections and abscesses are intensely FDG avid and are a potential mimic for the malignant process. The contrast enhancement pattern of an abscess helps to differentiate the two.

CECT shows the classical finding of the hypodense collection with an enhancing rim, which is typical for an abscess [Figure 8]. Thus, carefully inspecting the CT images, and doing a CECT helps in correct

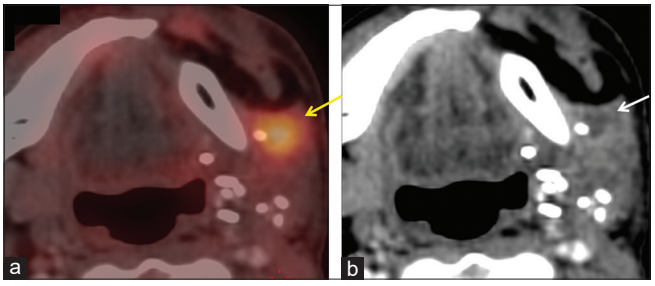

Figure 8: Abscess postsurgery. 51-year-old gentleman, squamous cell carcinoma of the left gingivobuccal sulcus, post left segmental mandibulectomy with fibula flap and skin graft. The patient presented with pain in the postoperative site. Fluorodeoxyglucose positron emission tomography/contrast-enhanced computed tomography was done 4 months after the surgery. The fused axial positron emission tomography/computed tomography image shows focal fluorodeoxyglucose avid area posterior to the flap (yellow arrow in a). In the axial contrast-enhanced computed tomography image, there is a hypodense collection, surrounded by an enhancing rim (white arrow in b) – this is a classical finding seen in an abscess

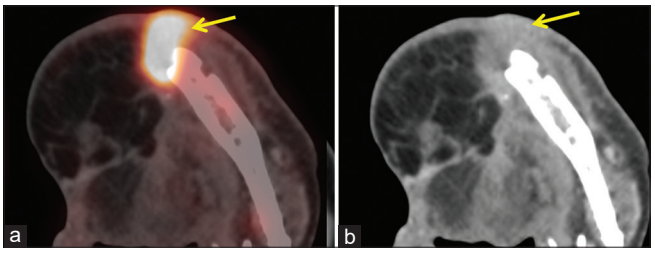

Figure 10: Recurrent disease at the flap site. 60-year-old gentleman, carcinoma of the right lower alveolus, post right marginal mandibulectomy. Fluorodeoxyglucose positron emission tomography/contrast-enhanced computed tomography was done 15 months after the surgery. Fused axial positron emission tomography/computed tomography image shows fluorodeoxyglucose avid, enhancing lesion in the periphery of the flap suggesting recurrent disease (arrow in a and b)

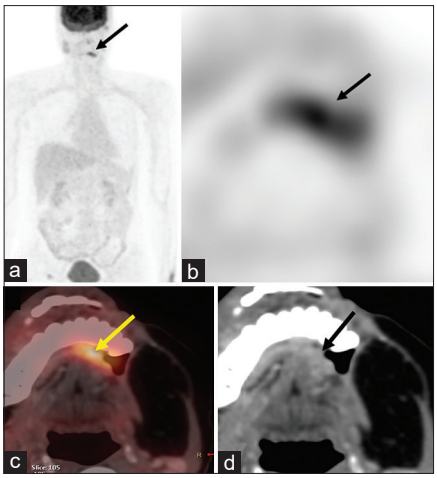

Figure 11: Recurrent disease. A 35-year-old young man had undergone left segmental mandibulectomy with pectoralis major myocutaneous flap and nodal dissection for carcinoma of the left retromolar trigone. Fluorodeoxyglucose positron emission tomography/contrast-enhanced computed tomography was done 14 months after the surgery. maximum intensity projection image shows an area of linear fluorodeoxyglucose uptake in the neck (arrow in a). Axial positron emission tomography and fused positron emission tomography/computed tomography shows an area of increased fluorodeoxyglucose uptake in the floor of the mouth (arrow in b, c) which shows intense enhancement on the contrast-enhanced computed tomography image (arrow in d)

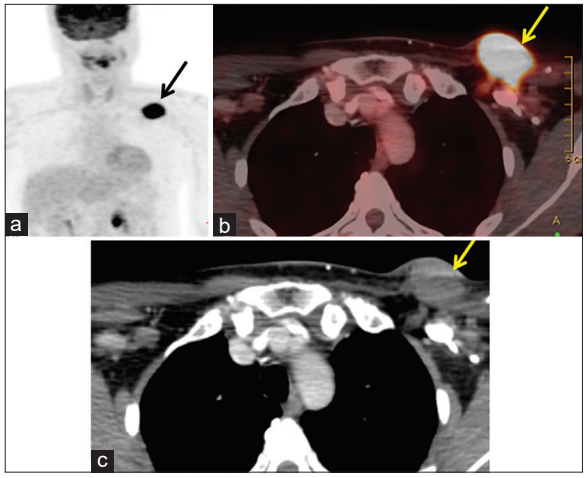

Figure 13: Donor flap site implant. 51-year-old gentleman, post reconstructive surgery (pectoralis major myocutaneous flap) for carcinoma tongue. The donor flap site was the left pectoralis major muscle. Positron emission tomography/computed tomography scan shows fluorodeoxyglucose avid, enhancing lesion in the left chest wall at the donor flap site in the maximum intensity projection and axial fused positron emission tomography/computed tomography and computed tomography images (arrow in a, b, c). Note the absence of left Pectoralis major muscle, being the donor site for pectoralis major myocutaneous flap

reporting.[7,9] Orocutaneous fistula (OCF) is another commonly encountered complication in patients operated for oral squamous cell carcinoma and shows intense FDG uptake [Figure 9]. This is often seen on 18F- FDG PET/CT as a linear area of intense FDG uptake tracking along the entire route of the fistulous track. The patient may present with a discharging fistula. The incidence of OCF ranges from 9% to 20%. This often delays the process of

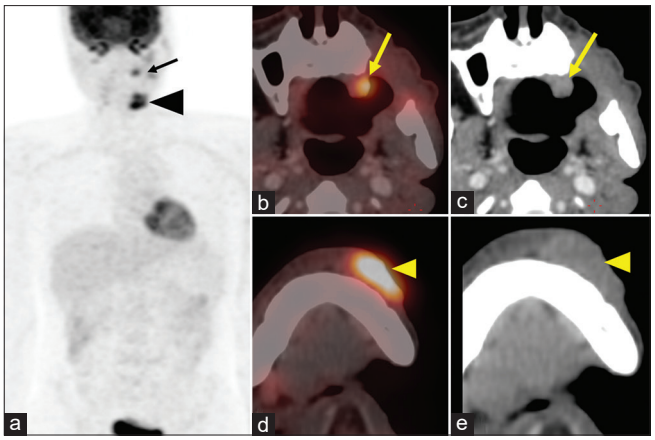

Figure 12: Two sites of recurrent disease in the same patient. 51-year-old gentleman, squamous cell carcinoma of the left buccal mucosa, post reconstructive surgery. Positron emission tomography/computed tomography scan shows fluorodeoxyglucose avid lesion in the anterior aspect of the flap in the maximum intensity projection and axial fused positron emission tomography/computed tomography images (arrows in a, b, c). Another hypermetabolic, enhancing lesion is noted the lower lip in the maximum intensity projection and axial fused positron emission tomography/computed tomography and axial computed tomography images (arrowhead in a, d, e)

wound healing and also delays the initiation of adjuvant treatment.[10]

Recurrent disease in head and neck cancers

18F- FDG PET/CT is the best imaging modality for the detection of recurrent disease in head and cancers, being superior to both clinical examination and conventional imaging.[11,12] Recurrent disease manifests as FDG avid, enhancing soft-tissue lesion, at the margins of the flap with loss of sharp boundaries with the adjoining structures [Figures 10 and 11]. Treated cases of head and neck malignancies have 10%–20% higher risk of second primaries.[13] But watch out for lesions in the same subsite in head and neck malignancies because as long as the lesion is in the same subsite, it translates to recurrent disease and not second primary [Figure 12]. In this case, both the lesions are in the same subsite - oral cavity. It is important to recognize the components of each subsite in head and neck cancers.[7] Recurrence of disease can also occur at the site of donor flap [Figure 13]. This is a rare and late complication post oral reconstructive surgery. Its occurrence is likely due to tumor implantation at the donor site during surgery.[14]

Conclusion

Postoperative FDG uptake due to wound healing, infections, and inflammations are common factors leading to misinterpretation on 18F- FDG PET/CT studies. Knowledge about the procedure, complications, appropriate timing, tailoring of the procedure, and familiarity with the common complications that occur during the postoperative period will assist us in differentiating the false-positive pitfalls from true-positive disease and in making an early, accurate diagnosis.

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