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FDG PET/CT in Head and Neck cancers and in Gliomas

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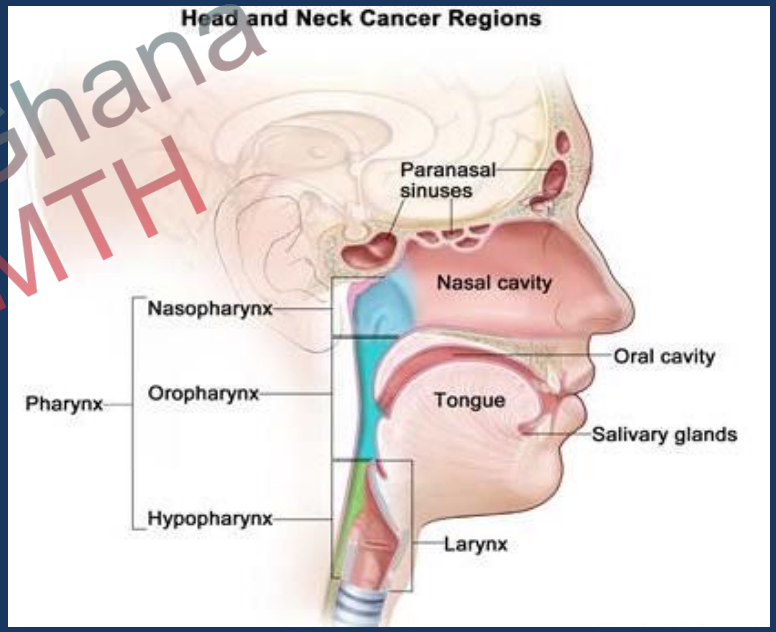
Cancers of the Head and Neck Region

Soft tissue cancers location :

- Nasopharynx
- Oropharynx
- Larynx (Hypopharynx)
- Paranasal tumors (maxillary & ethmoid sinus)
- Mucosal melanoma
- Oral cavity
- Salivary gland
- Lip



Head Neck Tumors Globocan data

- 7th most common cancer worldwide
- Greatest burden: low- and medium-income countries
- Men/women risk ratio: 2,3/1 (Globocan 2018)
- Histology: >90% squamous cell and adeno Carcinomas
- Prognosis: good to bad decreases significantly from early stage (80%) to locally advanced disease (40%)

Main Etiologies of Head Neck cancers

Most Commons - tobacco & alcohol

Epstein–Barr (EBV, nasopharynx ca) & Human papillomavirus (HPV, □ 50% oropharynx ca)

Biological complexity

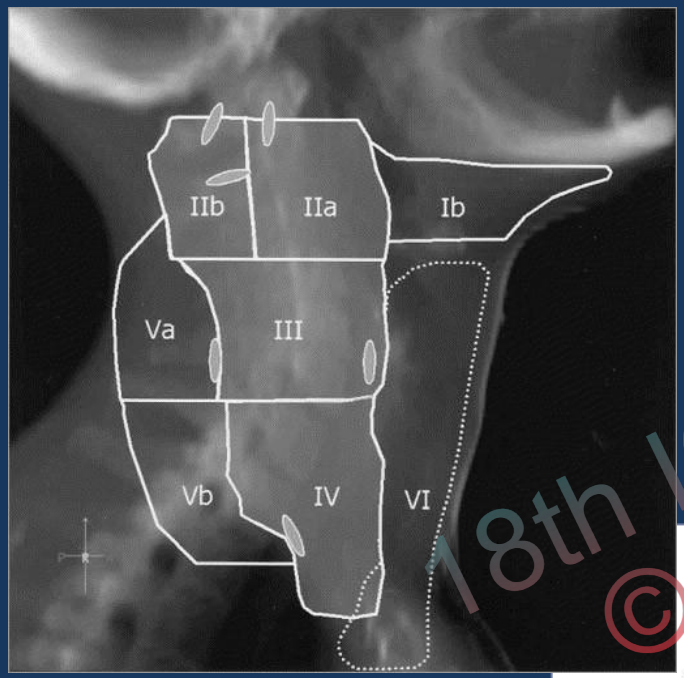
Structures invasion are linked to biological structures of the neoplasm

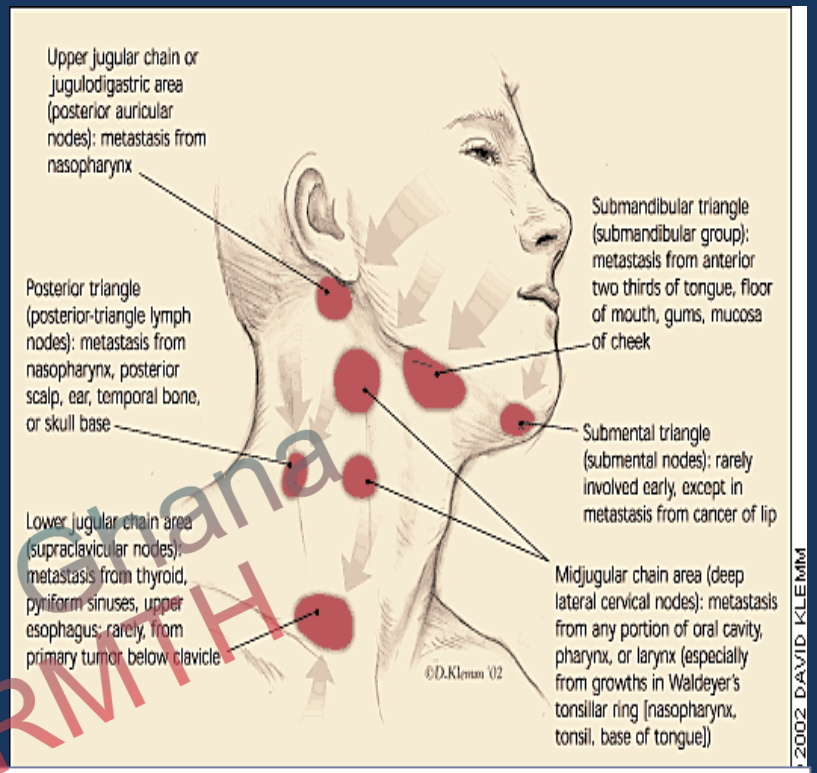
FDG-PET/CT in the Assessment of H&N Malignancies

Main Indications:

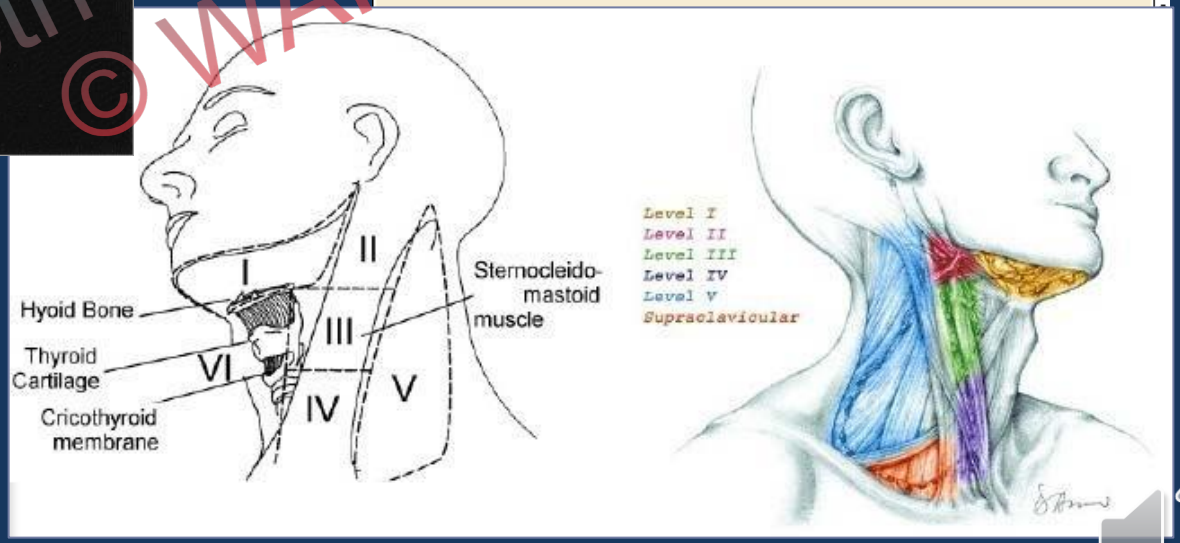
- Initial staging (N&M): nodal & distant disease
- Defining the prognosis (presence & degree of metabolic activity)
- Identify the primary lesion
- Diagnosis of recurrence and restaging
- Treatment planning
- Assessing treatment response

LN groups & levels I-VI in the H&N region





EORTC systematisation



LN Drainage of Head and Neck Malignancies

Region	LN drainage
Lip (upper & lower)	Submandibular, submental, subdigastric
Oral cavity	Subdigastric, upper jugular, submandibular
Oropharynx ((tongue, tonsillar, para-pharyngeal)	Upper, middle & deep cervical, subdigastric, para- & retro-pharyngeal
Nasopharynx	Retropharyngeal, deep cervical
Hypopharynx	Mid- & posterior cervical triangle, para- tracheal
Larynx (vocal cords, supra- & sub- glottis)	Subdigastric, mid-internal & inferior jugular
Paranasal (nasal fossa, frontal, ethmoidal, maxillary, sphenoid sinuses)	Submaxillary, base of skull, subdigastric, submandibular, jugulo-digastric
Salivary glands (parotid, submaxillary)	Preauricular, jugulo-digastric, intraglandular, submental

FDG-PET/CT for Assessment of LN Involvement in head and Neck Malignancies

Provides relevant information

- Number of nodes: single/multiple
- Distribution: ipsi-/contra-/bi-lateral
- Size
- Location: anatomic levels I-VI

Incremental synergistic data of PET/CT

- Metabolic (FDG): involvement of normal size nodes
- Anatomic (CT): presence of nodal mets adjacent to highly FDG-avid primary tumors

CONCLUSION

We found that high ^{18}F-FDG uptake (SUV > 6.0) was a marker for poor outcome in patients with SCC of the oropharynx, confirming earlier findings showing that pretreatment tumor ^{18}F-FDG uptake represents an independent prognostic factor in patients with head and neck cancers. To our

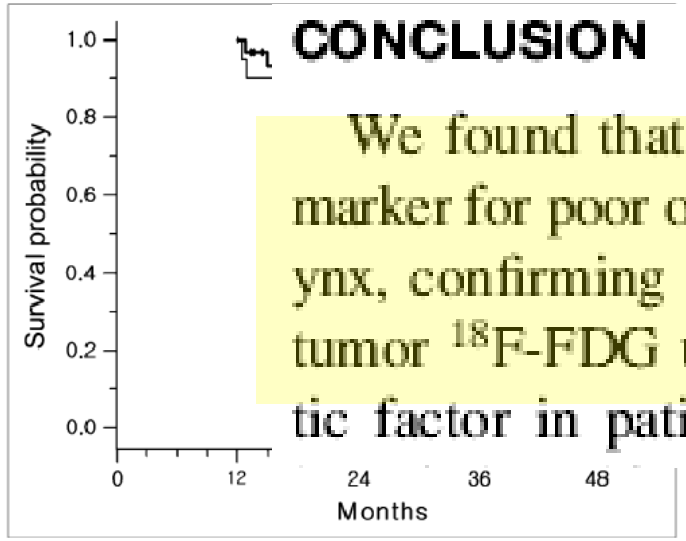


FIGURE 1. Actuarial DFS in patients treated with surgery (n = 31) or RT (n = 21) as primary treatment modality (P = 0.036).

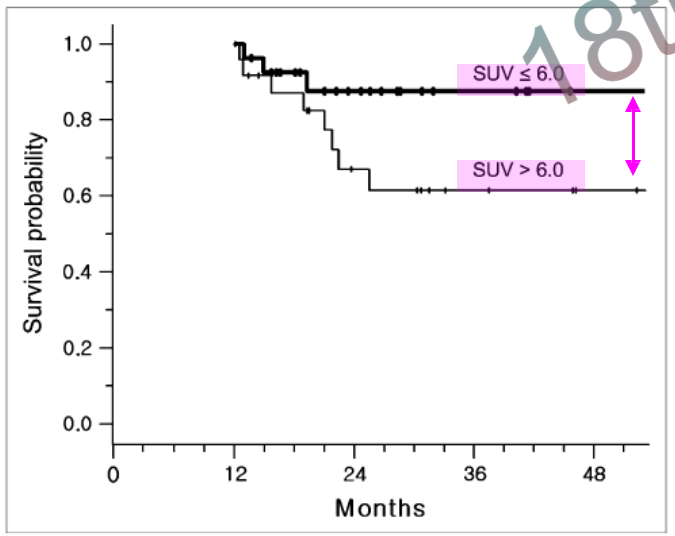


FIGURE 2. Actuarial DFS using cutoff of 6.0 for SUV of ^{18}F-FDG (low vs. high SUV, n = 27 vs. 25) (P = 0.036).

*Surgery group: surgery +

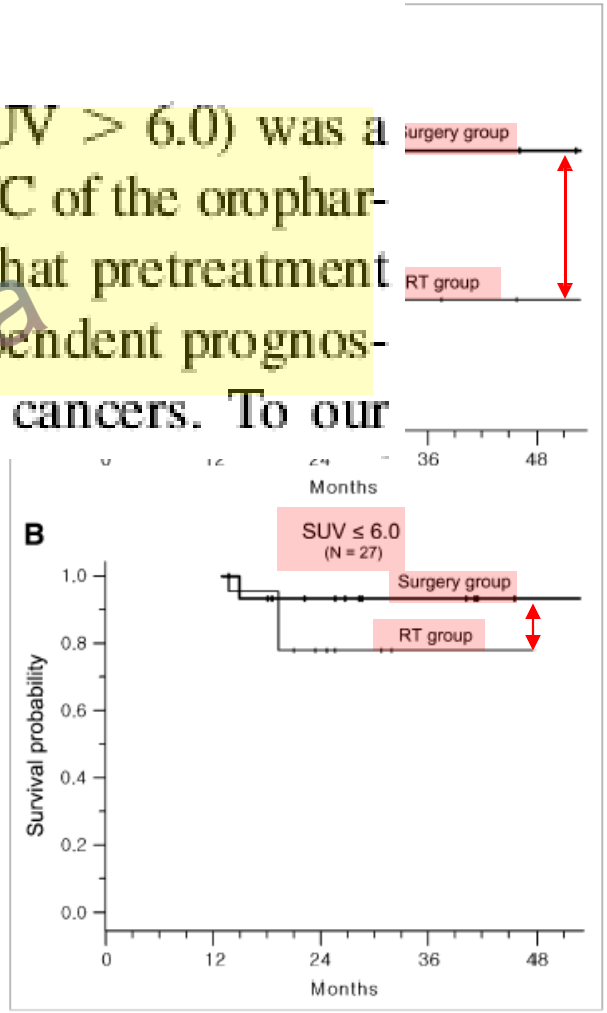


FIGURE 3. Actuarial DFS in patients treated with surgery or RT as primary treatment modality in patients with tumor SUV ≤ 6.0 and SUV > 6.0. In 25 patients with SUV > 6.0, primary surgery followed by RT (n = 15) resulted in a statistically better survival than did RT with chemotherapy (n = 10) followed by surgical salvage (A; P = 0.043). In 27 patients with SUV ≤ 6.0, there was no significant difference between surgery plus RT (n = 16) and RT plus chemotherapy (n = 11) (B; P = 0.329).

Evaluation of 18F-FDG PET/CT for diagnosing cervical nodal metastases in patients with oral cavity or oropharynx carcinoma

Yongnan Piao, MD,[a] Bayarkhuu Bold, MD,[a] Abulajiang Tayier, MD,[a] Ryuji Ishida, MD,[a] Ken Omura, DDS,[b] Norihiko Okada, DDS,[c] and Hitoshi Shibuya, MD, PhD,[a] Tokyo, Japan
TOKYO MEDICAL AND DENTAL UNIVERSITY
(Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2009;108:933-938)

Table IV. Comparison of sensitivity, specificity, PPV, NPV, and accuracy for node levels between Shöder Heiko group[9] and the present study results

	Shöder Heiko	*Present study*
TP	6	71
FP	6	24
TN	127	236
FN	3	14
Total	142	345
Sensitivity (%)	67	84
Specificity (%)	95	91
PPV (%)	50	75
NPV (%)	98	94
Accuracy (%)	94	89

PPV, Positive predictive value; *NPV*, negative predictive value; other abbreviations as in Table I.

Table III. Classification by size for cervical lymph nodes with the metastasis confirmed by histopathology

	PET/CT	
Size (mm)	*TP*	*FN*
Total	103	61

CONCLUSIONS

Combined PET/CT enabled the early detection of cervical nodal metastasis of oral or oropharynx cancers, but the diagnosis of metastasis was not accurate if the metastases had a maximum diameter of <10 mm. Combined PET/CT can accurately detect lymph node metastases levels to supply good information to surgeons for early treatment of patients.

Table 1 Patient Characteristics

Characteristic	Total
Total	212
Gender	
Male	124
Female	88
Age (median, years)	58
Tumor Site	
Stage	
T0	13
T1-2	66
T3-4	120
Recurrent	13
N0	78
N1	36
N2-3	98
Chemotherapy	159
Surgical resection	42

Kubicek *et al. Head & Neck Oncology* 2010, **2**:19
http://www.headandneckoncology.org/content/2/1/19

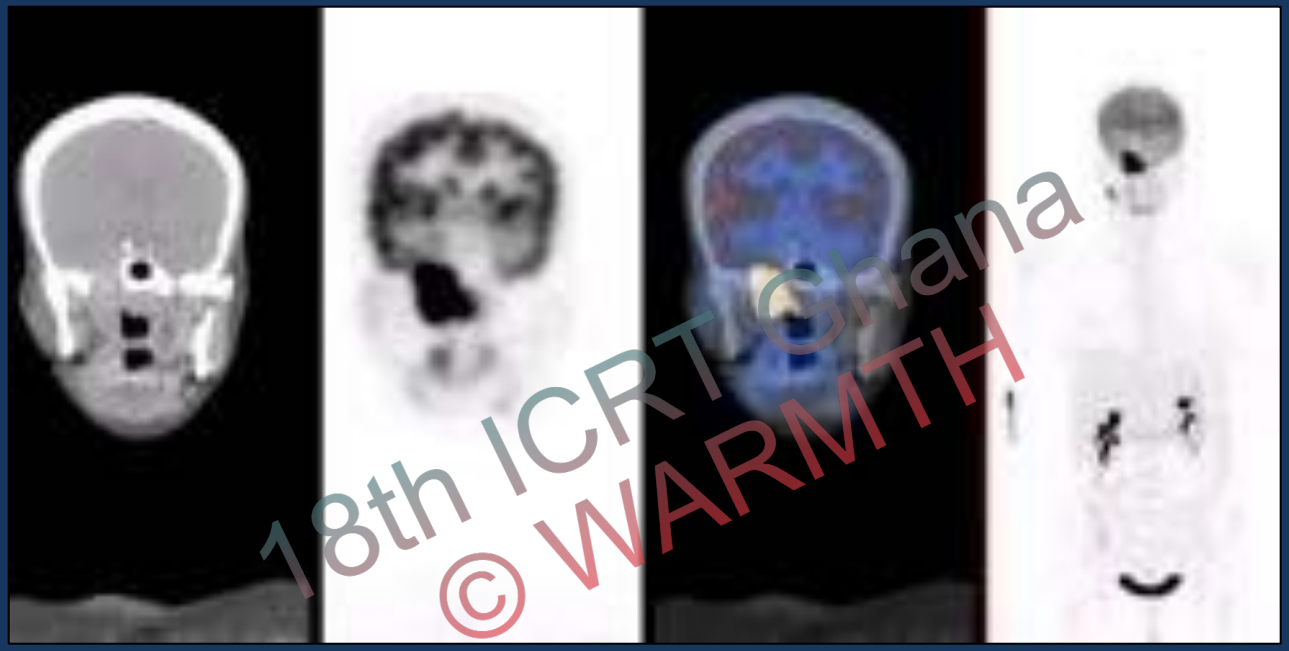
Head & Neck Oncology

RESEARCH Open Access

FDG-PET staging and importance of lymph node SUV in head and neck cancer

Gregory J Kubicek[1,2,3*], Collin Champ[1], Shannon Fogh[1,4], Fen Wang[2], Eashwer Reddy[2], Charles Intenzo[1], Reginald W Dusing[2], Mitchell Machtay[1,5]

FDG-PET/CT for T-Staging
Nasopharynx Carcinoma with Extension to Base of Skull



Role of FDG-PET/CT for T-staging, Role of PET/MR

- Limited value, less anatomy detail vs. MRI
- MRI required for planning surgery & radiotherapy
- Important role of PET/MR

2nd Primary Tumors (Synchronous or Metachronous)

Risk for 2nd primary neoplasms:

- Synchronous –within 6 months: 1.4 –18%
- Metachronous –after 6 months, within 5 years: >20%

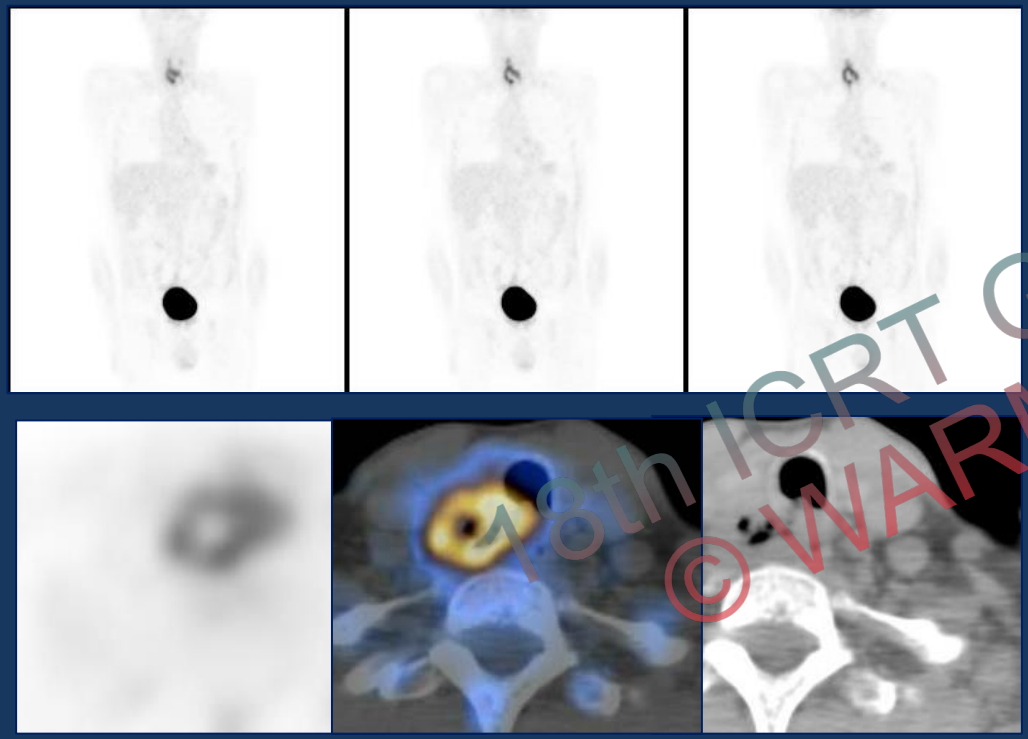
Location:

- Larynx or pharynx
- Lung
- Eosophagus

Performance indices of FDG-PET/CT:

Sensitivity: 87%, Specificity 95%

Larynx Ca & 2nd Metachronous Primary Tumor in Esophagus

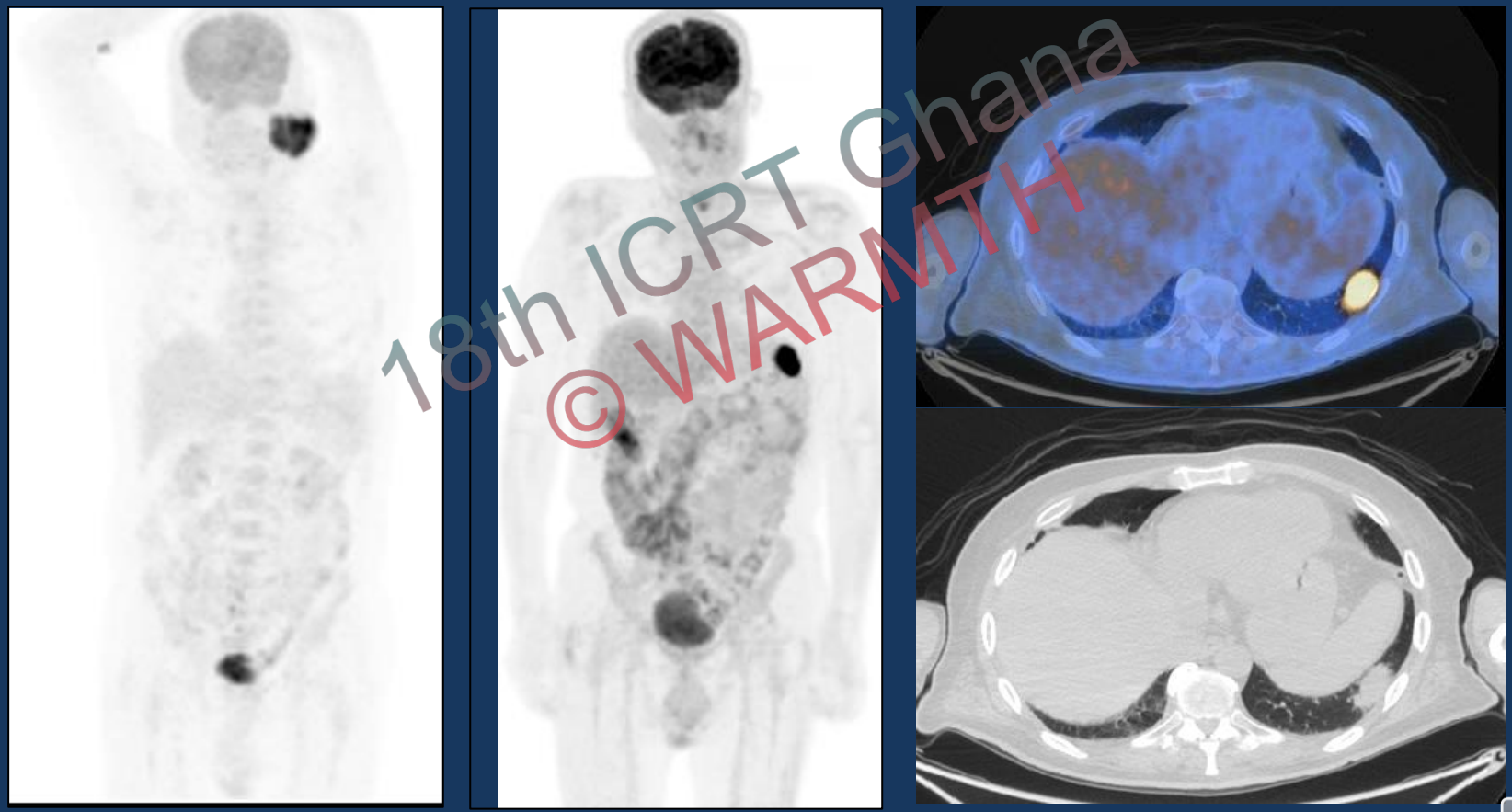


Larynx cancer

FDG+ focus in anterior neck localized to proximal esophagus

Larynx and esophagus cancers

Left Parotid carcinoma and Primary in Left of Lung



^{18}F-FDG PET as a Routine Posttreatment Surveillance Tool in Oral and Oropharyngeal Squamous Cell Carcinoma: A Prospective Study

J Nucl Med 2009; 50:1940–1947
DOI: 10.2967/jnumed.109.065300

TABLE 3. ^{18}F-FDG PET and Regular Follow-up Performances at Patient Level

Modality	TP	FN	TN	FP	Sensitivity	Specificity	PPV	NPV	Accuracy
^{18}F-FDG PET	18*	—	13	17	100%†	43%	51%†	100%†	65%†
Regular follow-up	—	18	18	12	0%	60%	—	50%	38%

TABLE 4. Accuracy of 156 Serial ^{18}F-FDG PET Scans in Detecting Persistent, Recurrent, or Metastatic HNSCC Overall and at Different Anatomic Sites

Area	TP	FN	TN	FP	Sensitivity	Specificity	PPV	NPV	Accuracy
All regions	30 (50)	1	90	35 (15)	97% (98%)	72% (86%)	46% (77%)	99% (99%)	77% (90%)
Head	16 (32)	—	118	22 (6)	100% (100%)	84% (95%)	42% (84%)	100% (100%)	86% (96%)
Neck	7 (8)	—	142	7 (6)	100% (100%)	95% (96%)	50% (57%)	100% (100%)	96% (96%)
Distant	16 (23)	1	128	11 (4)	94% (96%)	92% (97%)	60% (85%)	99% (99%)	92% (97%)

In parentheses are false-positive results with known pathologic substrates other than malignancy, such as mucositis or fractures, that were counted as true-positive.

TP = true-positive; FN = false-negative; TN = true-negative; FP = false-positive; PPV = positive predictive value; NPV = negative predictive value.

MOLECULAR IMAGING AND BIOLOGY

Published Online: 5 June 2008

Mol Imaging Biol (2008) 10:224–229
DOI: 10.1007/s11307-008-0145-4

RESEARCH ARTICLE

Prognostic Value of FDG-PET in Patients with Oropharyngeal Carcinoma Treated with Concurrent Chemoradiotherapy

Keisuke Enomoto,[1,2] Hidenori Inohara,[1] Ichiro Higuchi,[2] Kenichiro Hamada,[2] Yoichiro Tomiyama,[1] Takeshi Kubo,[1] Jun Hatazawa[2]

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Table 2. Diagnostic accuracy of post-CRT assessment in local and regional recurrence of disease (n=18)

	PPV (%)	NPV (%)	Accuracy (%)
Local recurrence			
CT (+CE)	100 (22–100)	82 (78–82)	83 (75–83)
FDG-PET	100 (22–100)	82 (78–82)	83 (75–83)
Regional recurrence			
CT (+CE)	67 (36–86)	83 (68–93)	78 (57–91)
FDG-PET	100 (67–100)	92 (79–92)	94 (76–94)

Number in parentheses are 95% CI
PPV positive predictive value, *NPV* negative predictive value, *CE* contrast enhancement

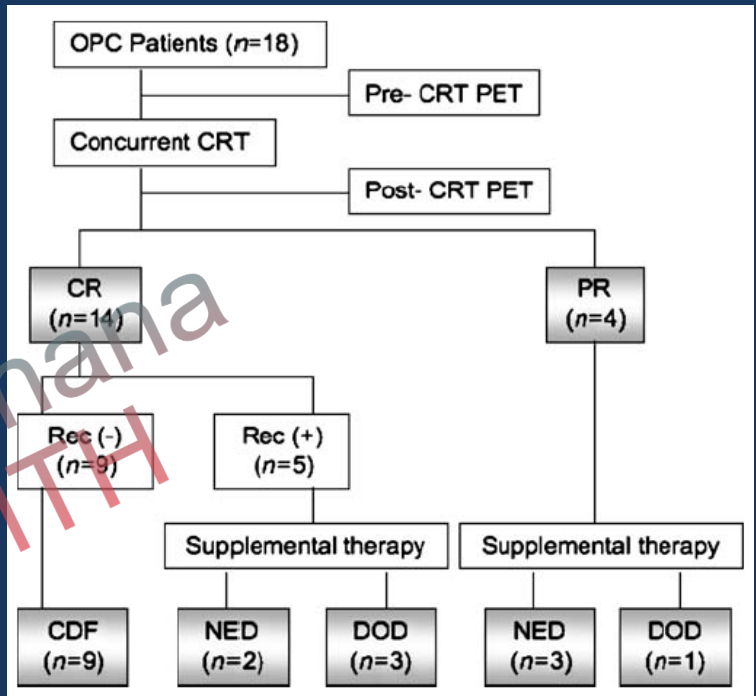


Fig. 1. Flow chart showing the distribution of the patients' outcome. *OPC* squamous cell carcinoma of the oropharynx, *CRT* chemoradiotherapy, *CR* complete response, *PR* partial response, *Rec* recurrence, *CDF* continuous disease-free, *NED* no evidence of disease, *DOD* died of disease.

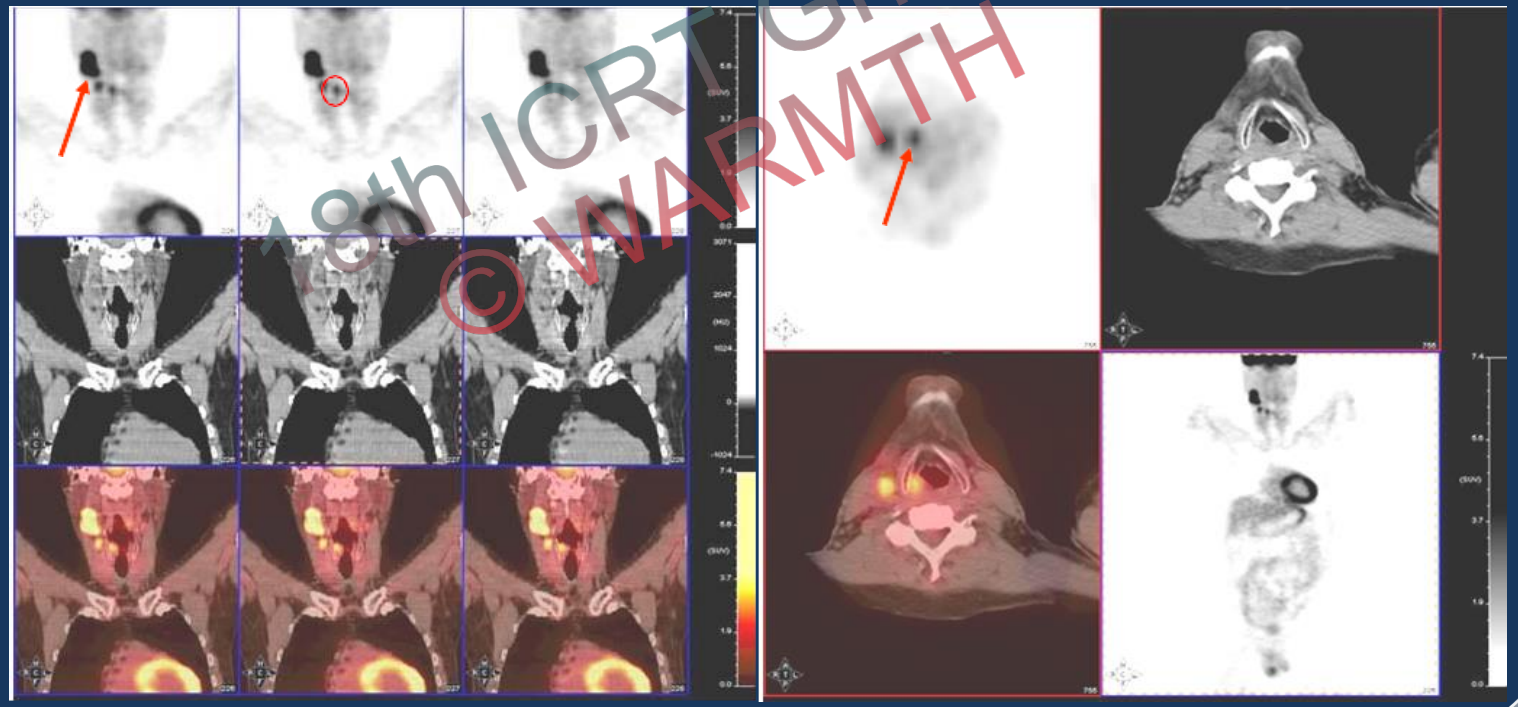
In conclusion, the predictive value of post-CRT FDG-PET is superior to that of conventional CT scan in OPC patients. The OPC patients with positive FDG-PET after CRT exhibited poor survival. In contrast, negative PET studies after CRT indicated good prognoses. The results of post-CRT FDG-PET should be included in the management of the OPC patients.

FDG PET/CT imaging of head & neck cancer
Indications FDG

FDG PET/CT. Carcinoma of unknown primary : Lymph node metastases from squamous cell carcinoma

PET/CT is around 50%

SUVmax=11.2 Undifferenciated Carcinoma
SUVmax=4.1 Right vocal cord



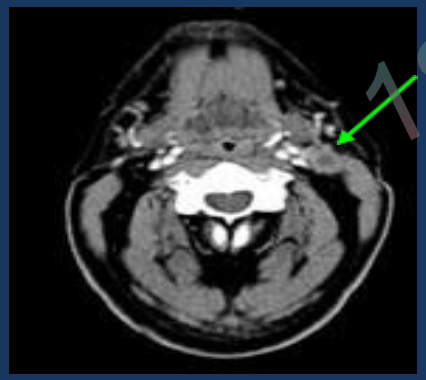
FDG PET/CT imaging of head & neck cancer : Detection of disease recurrence

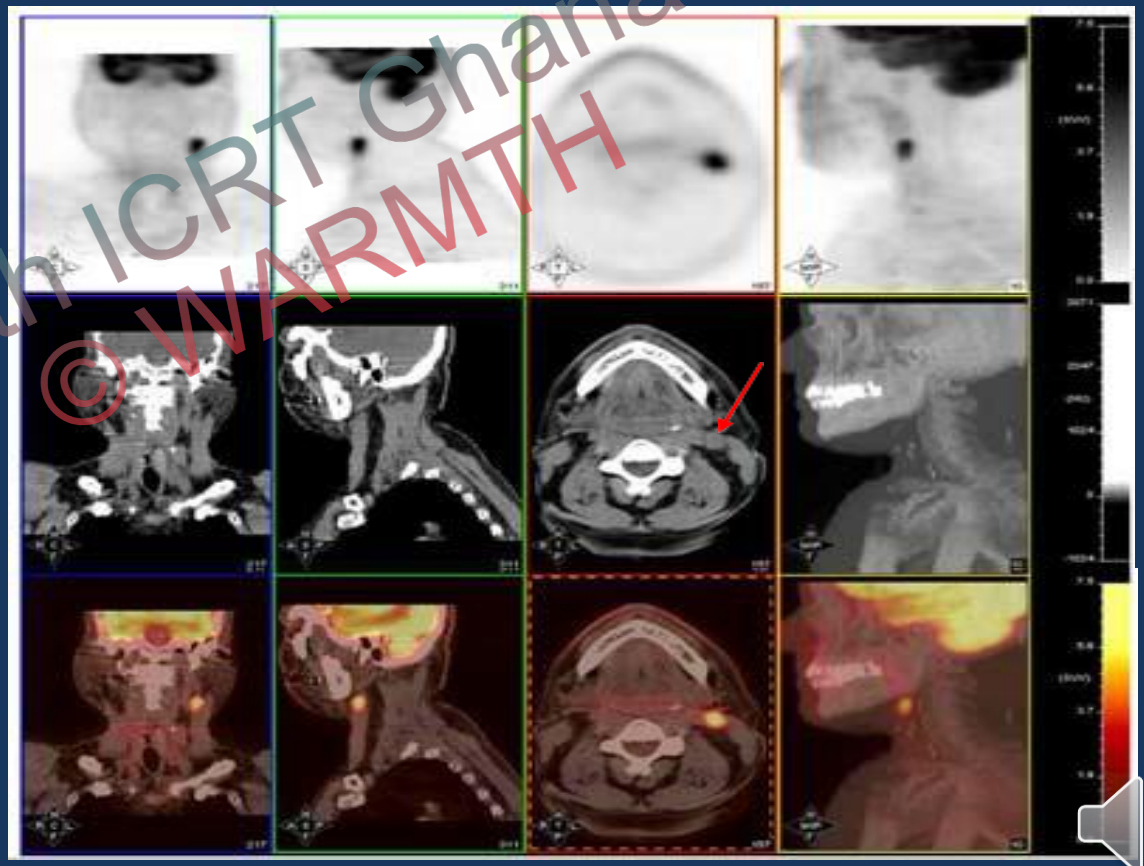
FDG PET/CT imaging of head & neck cancer : Detection of disease recurrence

- FDG PET higher diagnostic accuracy than CT/MRI

SUVmax=6.8

Laryngectomy Uncertain recurrence





ASSESSMENT OF THERAPY RESPONSE

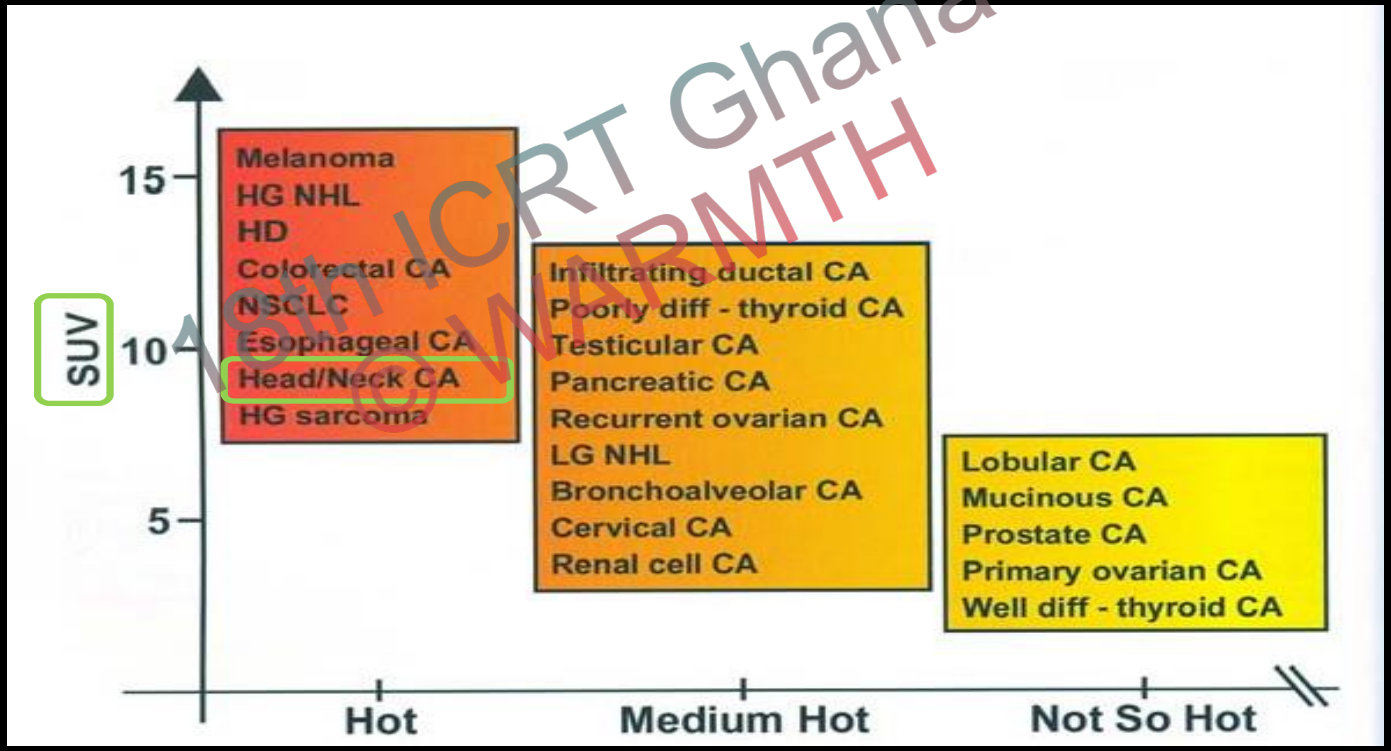
- **Qualitative**
- **Semiquantitative**
- **Quantitative**

$$SUV = \frac{\text{tissue concentration (Bq/g)}}{\text{injected dose (activity Bq) / weight (g)}}$$

SUV = 20

SUV = 1

PET/CT FDG Quantification



FDG PET/CT imaging of head & neck cancer : Detection of disease recurrence: False positives causes

- Previous treatments produce distortion
  - Mucosal surfaces
  - Tissue planes
  - Anatomical structures
- Difficulty in interpreting CDT
  - Soft tissue edema
  - Inflammation
  - Fibrosis
- Early detection of recurrence increases the likelihood of effective treatment.

Optimal Use of FDG-PET/CT in H&N Tumors

Johnson et al, Laryngoscope 2014

FDG is less indicated:

- When there is no diagnosis of malignancy (only clinical suspicion)
- In pretreatment staging of stage I/II tumors
- In known non-/less- FDG avid malignancies (e.g. Thyroid Ca)

Caution:

- salivary gland tumors (highly FDG-avid benign lesions)

Data demonstrate:

- Therapeutic advantages of early detection of recurrence (by 6-12 mo. to clinical symptoms)
- Improved loco-regional control or DFS using FDG-PET/CT surveillance

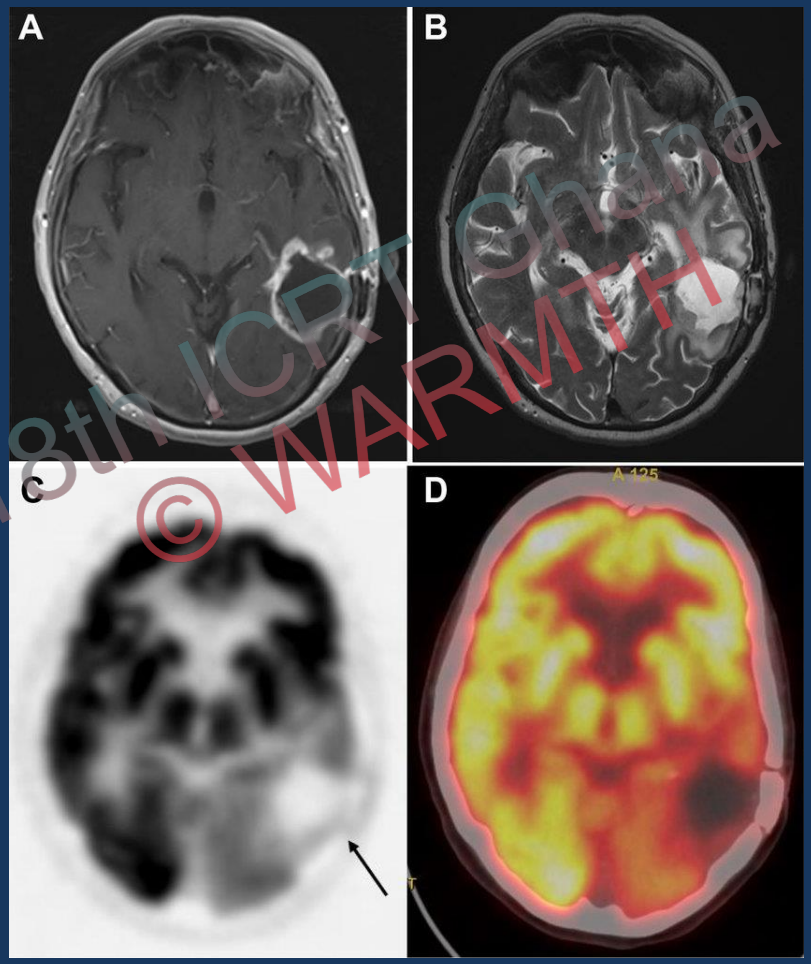
FDG-PET/CT in H&N Tumors

NCCN Clinical Practice Guidelines update 2022

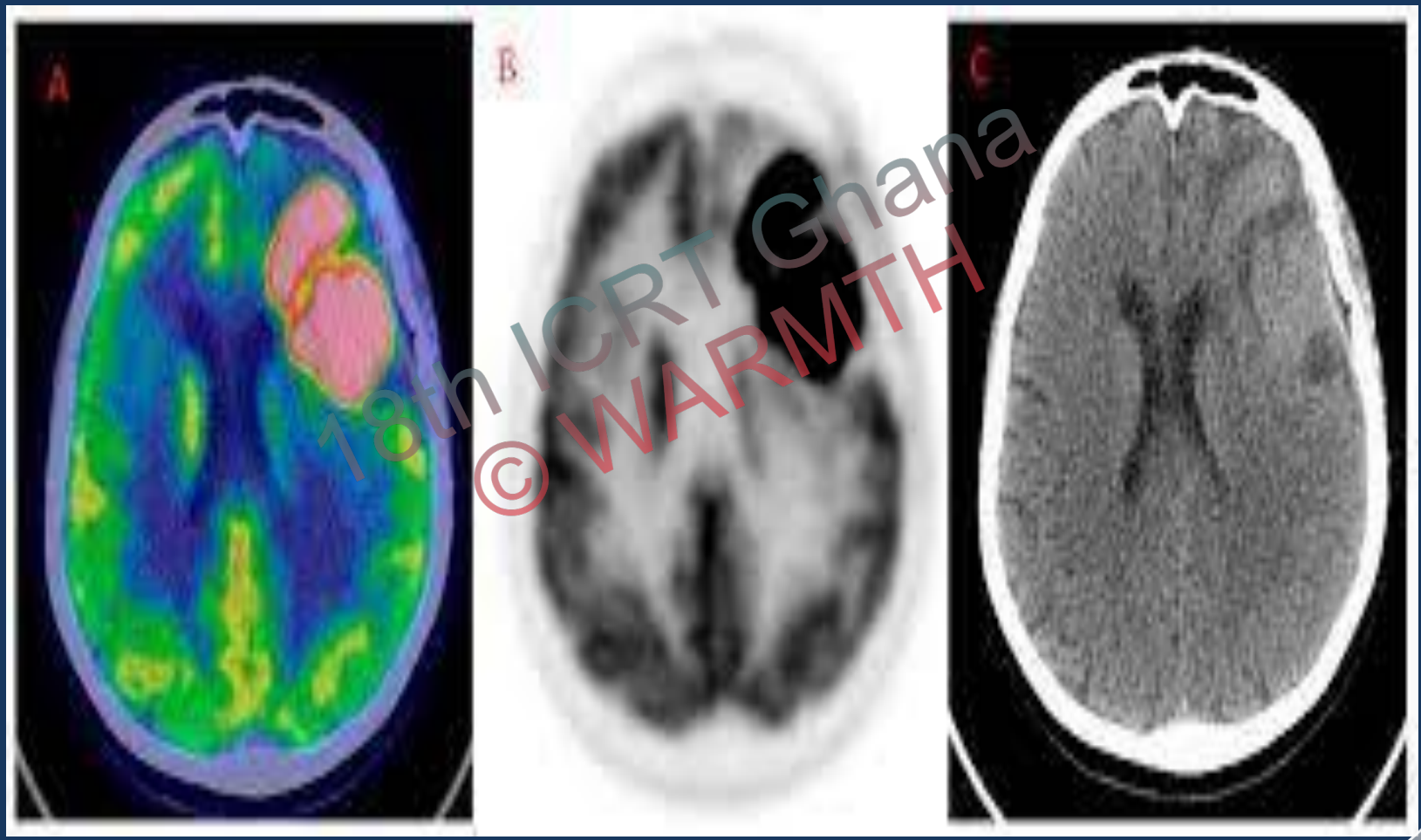
Recommend FDG-PET/CT for:

- **Initial staging of seemingly advanced disease** (stage 3 & 4): oral cavity, oro- & hypo-pharyngeal, larynx cancer
- **Distant metastatic work-up**: nasopharyngeal cancer (N2-3 disease), mucosal melanoma
- **Evaluation of Cancer of unknown primary** presenting with a neck mass
- **Post-treatment evaluation in patients with NO & clinical suspicion of active disease** (at 12 weeks), further management relies on results of FDG study; if negative optional to proceed with further cross-sectional imaging

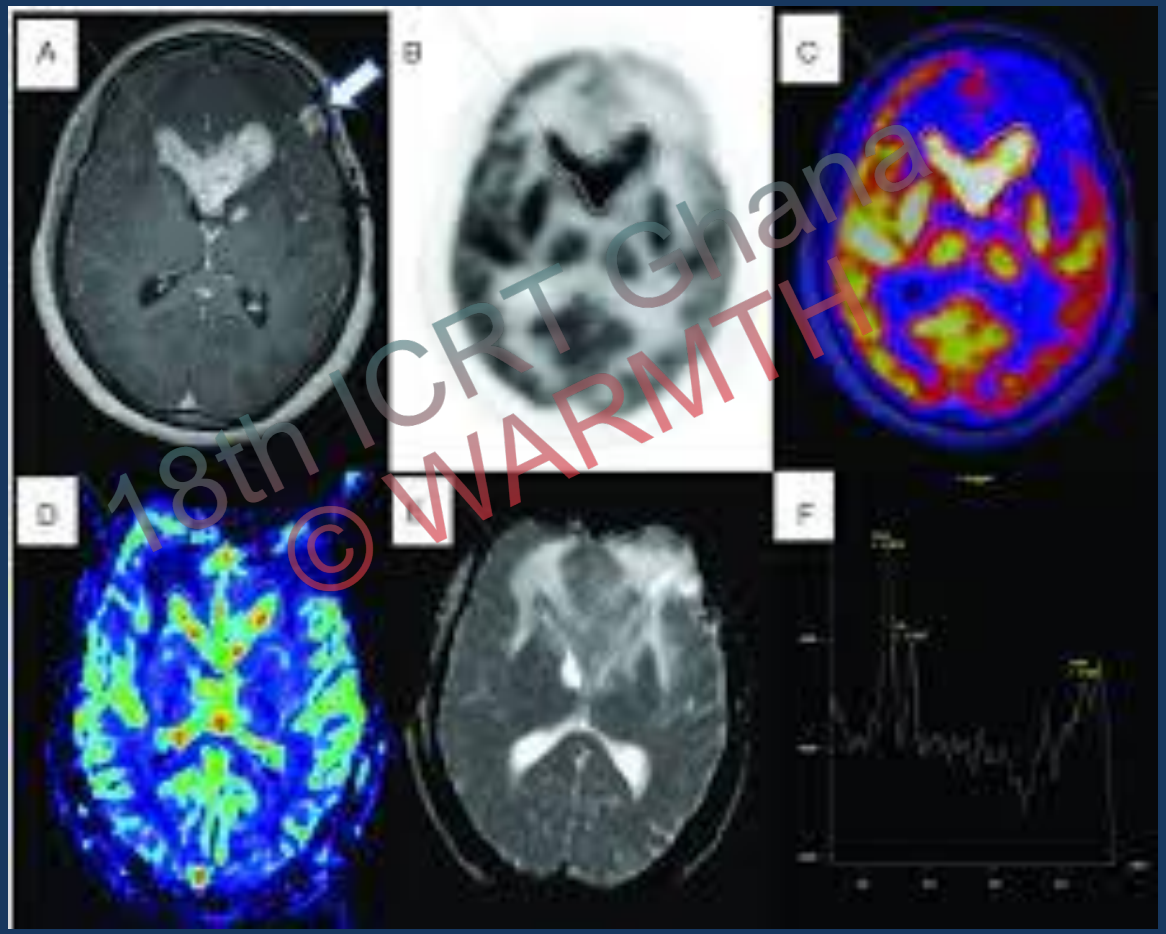
Non active suspicion of relapse of Gliobastoma FDG PET: : Necrosis process



Very active Gliobastoma on FDG PET: High Grade



Non active suspicion of relapse of Gliobastoma FDG PET: : Necrosis process



Conclusion

Advanced imaging techniques with FDG PET/CT and PET/MR :

- Demonstrate metabolic heterogeneity within most gliomas
- Provide localised and specific information that is useful for planning and monitoring of treatment
- Targeting of biopsies
- Early detection of recurrence
- Imaging needs integration with multidisciplinary glioma management
- PET Imaging has shown its potential to increase the efficiency of therapeutic