MEASUREMENTS OF DOSE RATE CONSTANT CORRECTED FOR SELF ATTENUATION FROM PATIENTS INJECTED WITH ^{18}F (FDG).

Khaled Soliman, Ahmed Alenezi

Medical Physics Department; Prince Sultan Military Medical City. Riyadh, Saudi Arabia

aalenezi@psmmc.med.sa

ksoliman@psmmc.med.sa

Purpose/Introduction

Variations in FDG biodistribution and organ uptake levels are patient specific and vary with organs sizes and disease types. Radiation self-attenuation and scatter characteristics are assumed to be patient specific and may have comparable variations among populations.

A new study from different population type or race could positively contribute to the overall average value applicable in clinical practice.

The aim of this paper is to recommend a value for the radiation dose rate constant measured at one meter from patients injected with ^{18}F-FDG to be applied in clinical practice.

Table (1): list of some of the reported dose rate constant for ^{18}F in the literature

Year	Authors	Dose rate constant in (µSv/h/GBq)
2012	Ninkovic [8]	135.1
2012	Smith and Stabin [9]	149
2008	IAEA [10]	147
1992	Shleien [11]	169
1992	Tschurlovits [12]	137
1982	Unger and Trubey [13]	185

Table (2): list of some of the reported dose rate constant measured directly from patients injected with ^{18}F-FDG in the literature

year	Authors (number of patients)	Dose rate constant in (µSv/h/GBq)
1992	Kearfott [14]	75
1997	Chiesa [15] (53)	55
1999	Cronin [16] (75)	100
2000	Benatar [17] (115)	150
2000	White [18]	137
2012	Quinn [4] (152)	95

Methods

The dose rate from the patient is given by the following equation:

$D_P/A = G\ C_g\ C_a$ (1)

Where:

D_P/A: is the measured dose rate from the patient per unit of injected activity in [$\mu Sv.h^{-1}.GBq^{-1}$]

G: the Gamma dose rate constant in [$\mu Sv.m^2.h^{-1}.GBq^{-1}$].

C_g: is a correction factor correcting for the source geometry and the distance from the source to the measuring point.

$C_g = 1/r^2$: for the point source approximation (2)

$C_g = \tan^{-1}(L/2r)/(Lr/2)$: for the line source approximation (3)

L: is the source length in [m] and r is the distance between the source and the measuring point in [m].

Figure 1 shows Cg for line source.

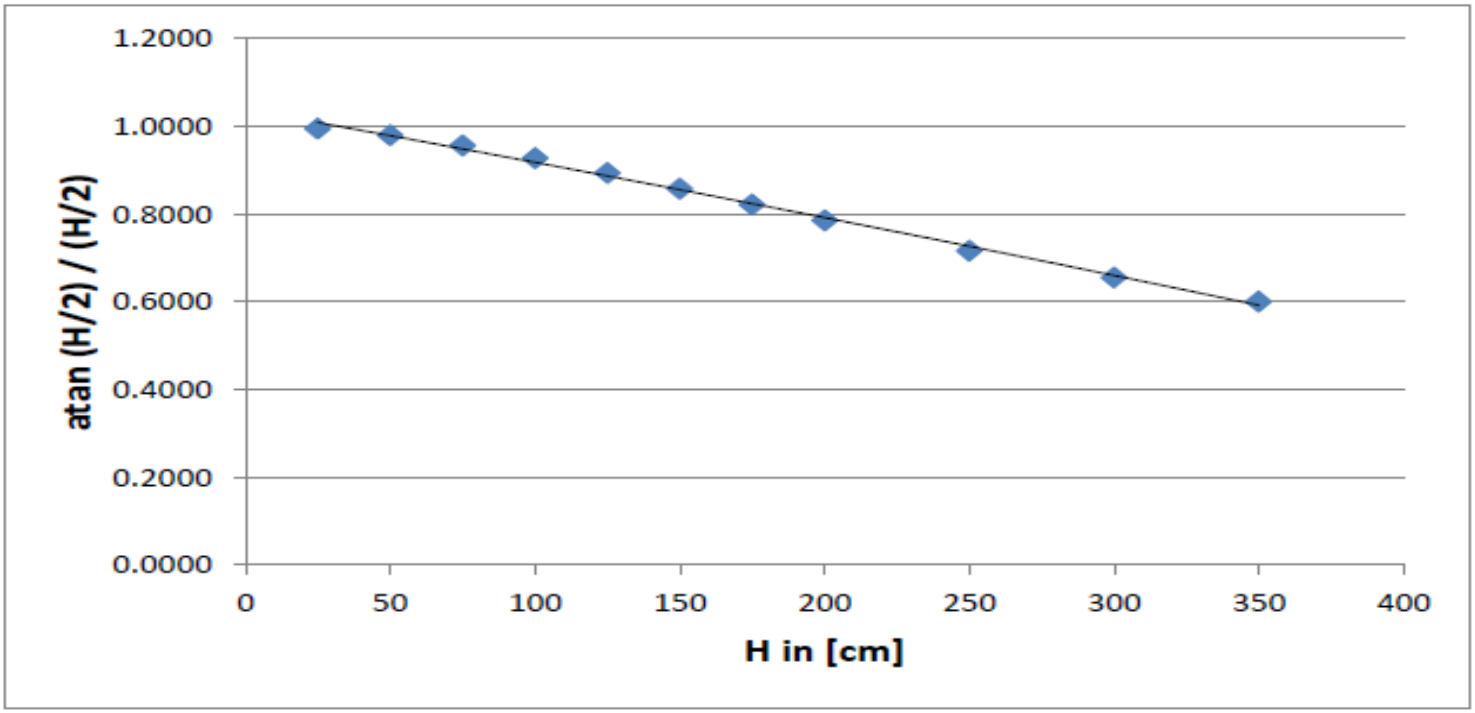

Figure 1: Source shape correction factor (C_g) as function of the patient's height in cm.

C_a: is a correction factor correcting for the patient body self attenuation assumed to be equal

$$C_a = 1 - \text{Exp}(-\mu T/2) \quad (4)$$

Where μ is the linear attenuation coefficient and T is the patient body thickness. In this work we have calculated attenuation factors (C_a) for a range of body sizes see Figure 2.

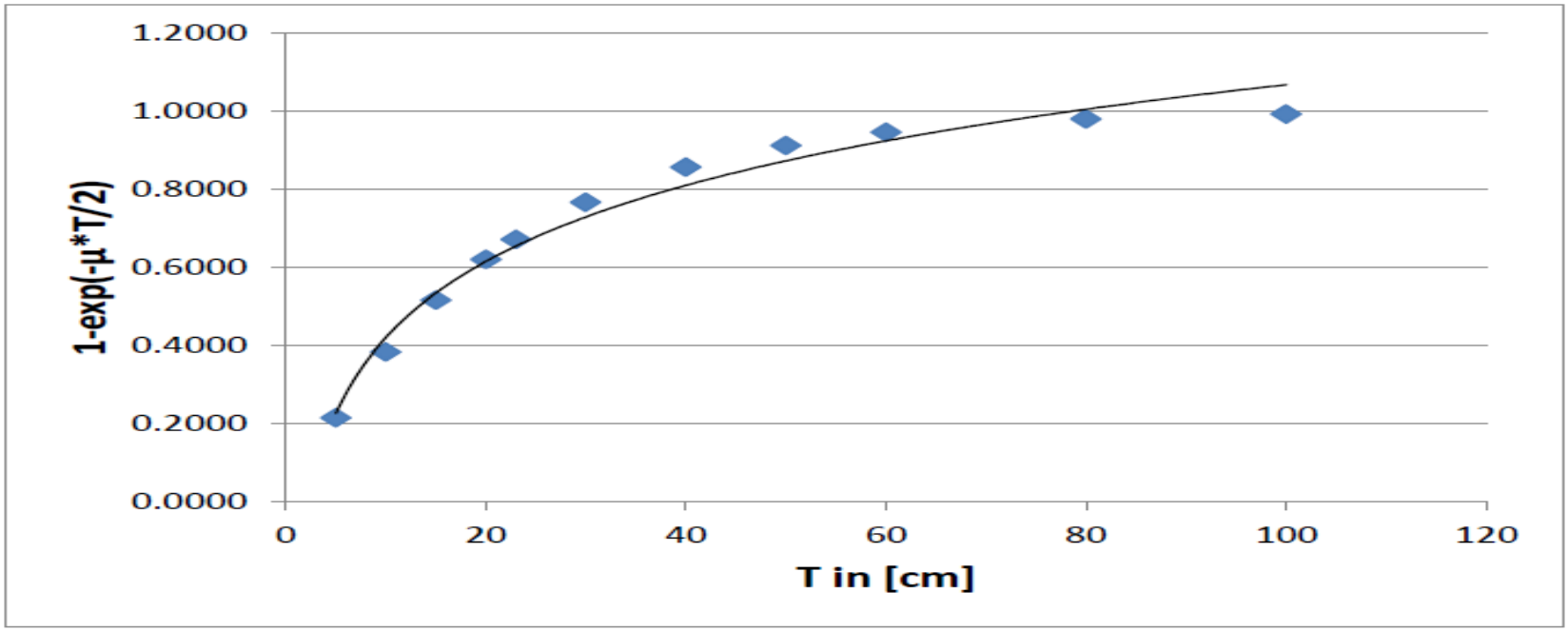

Figure 2: Patient body Attenuation Correction (C_a) as function of body thickness (T) in cm. μ = 0.09687 cm^{-1} for 500 kev photons

Results

We have measured the dose rates from 67 patients all injected with ^{18}F-FDG just before voiding using a calibrated ionization chamber; The injected activity was corrected for decay and used to calculate the dose rate per unit activity constant.

The injected activity range was [147-485] MBq and we found an average dose rate constant of 96±14 $\mu Sv.h^{-1}.GBq^{-1}$.

model	Measured/Calculated Ratio	r2	(M-C)/M %
TG-108 recommended value	0.96	0.616	11.1%
20 cm thick patient (Point Source)	0.99	0.593	11.2%
23 cm Thick Patient (point source)	0.92	0.593	14.6%
23 cm Thick Patient (line source)	1.1	0.585	12.2%

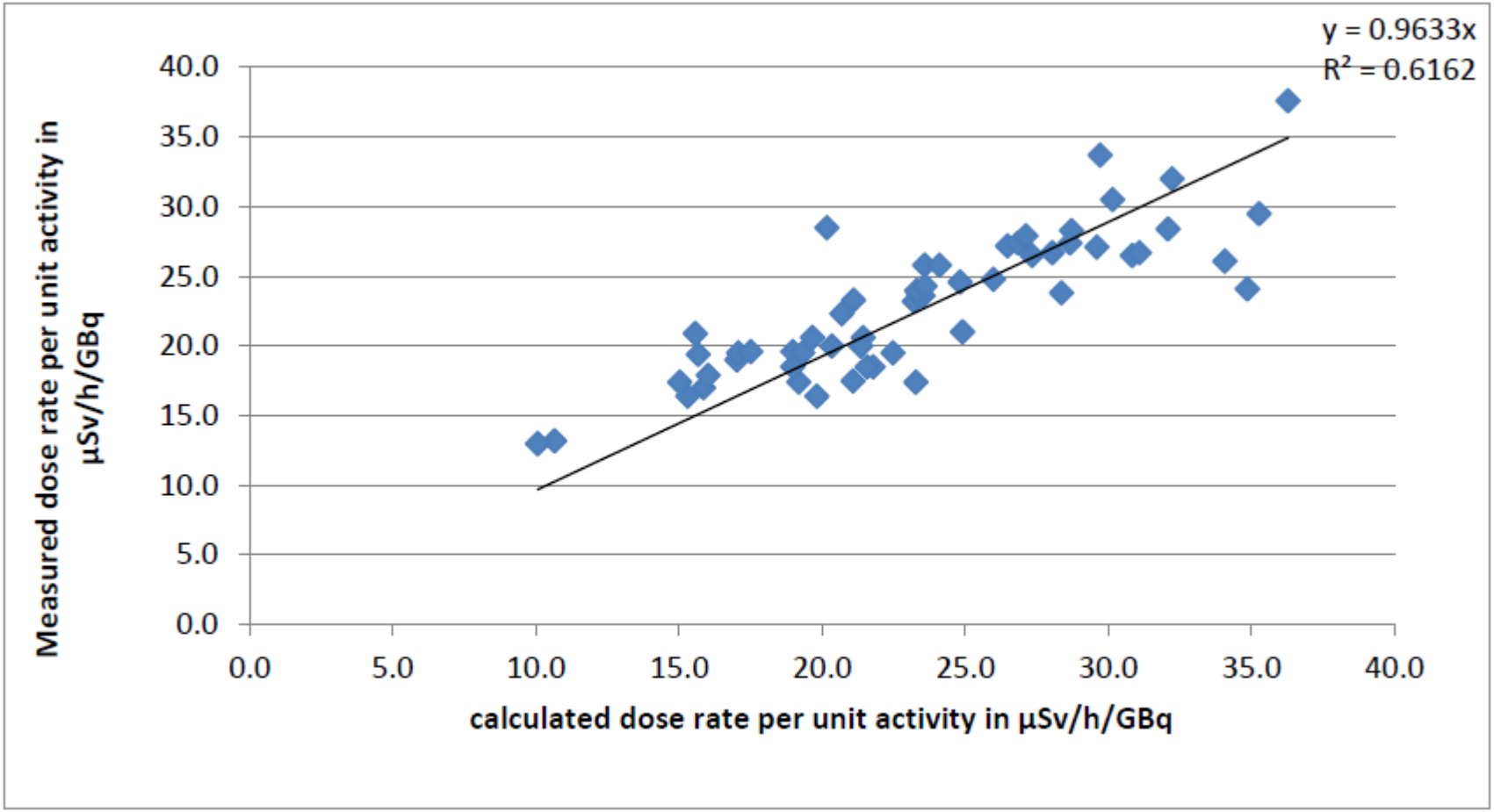

Figure 3: Measured dose rates as a function of the calculated ones using AAPM TG-108 recommended value for 57 patients.

Conclusions

we recommend the use of 96 $\mu Sv.h^{-1}.GBq^{-1}$ as radiation dose rate constant evaluated at one meter from patients; this result is in agreement with the current literature in ^{18}F-FDG PET/CT imaging practice.

We have examined the geometrical factors affecting the measured dose rate values, specifically the point and line source models

We have presented an overview of the literature that reports dose rate constant values calculated using different assumptions, and suggest the most appropriate one to be used in the case of occupational radiation dose estimates without performing actual dose rate measurements on the patient.