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Evaluation Of ^{99m}Tc- MAG3 \DTPA Radiopharmaceuticals In Detection Of Hydronephrosis

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Abstract

Renal scintigraphy using 99mTc-diethy-lenetriamine pentaacetic acid (DTPA) or mercaptotriglycine (MAG-3) with administration of frusemide in (diuretic renography) is used to estimate absolute and differential renal function in different pathological conditions; Nuclear Medicine Scintigraphy has provided a unique tool for the noninvasive evaluation of renal pathophysiology. Hydronephrosis is one of endemic diseases in Sudan which can affect the kidneys in both short and long time intervals leading to renal failure in future. The aim of this study was to evaluate the use of quantitative T ½ value in detection of obstructive and non-obstructive hydronephrosis using both radiopharmaceuticals (99mTc-MAG3 and 99mTc-DTPA) and to define the T ½ ranges of each Type of (HyN) in Sudan, and to find out the radiopharmaceutical of the choice in detection of hydronephrosis, Between Jan 2009 and November 2009, 100 patients suffering of hydronephrosis divided into two groups in two different hospitals (RICK,ELNILINE), each group (50 patient) of patients were injected with different radiopharmaceutical (group 1 with 99mTc-MAG3 in RICK) and (group 2 with 99mTc-DTPA in ELNILINE), The Standardized diuretic renograms were obtained in nuclear medicine centers T ½ ranges for obstructive (HyN) were the range of (<12min) and for Non-obstructive (HyN) were in the range of (<8-12). Drainage half-time clearance (T ½) were lower in all the cases of (HyN) injected with 99mTc-MAG3 than cases been injected with 99mTc-DTPA, which make it the radiopharmaceutical of the choice in detection of (HyN). This sudy concluded that 99mTc-MAG3 showed lower T ½ readings in comparison with 99mTc-DTPA which indicates that 99mTc-MAG3 is cleared faster than 99mTc-DTPA in all the pathological conditions of hydronephrosis (Non-obstructive and Obstructive HyN)

Key Words: MAG3 ,DTPA , Radiopharmaceuticals

INTRODUCTION

Renal imaging is the ability to monitor biochemical and physiological function of the organs as in vivo method Renal Imaging can include ultrasound, MRI imaging, computed tomography (CT) and the use of radioisotopes as radiotracers. Radioisotope imaging involves the ingestion of a radioisotope to help visualize an organ in the body using certain radioisotopes which are readily absorbed by the kidneys, and this radioisotope is a tracer that probes an image and the functioning of the kidneys.

The use of radioisotopes in the studies of the urinary system is dedicated for three major goals: as quantification of renal function, dynamic imaging i.e. renography and parenchymal scintigraphy (Baert and Leuven, 2006).Despite recent technical advances in CT, magnetic resonance, and ultrasound imaging, nuclear medicine (NM) has maintained its crucial role in the functional assessment of the urinary tract, particularly the kidneys. For hydronephrosis, the detection and evaluation could be carried out by using the following radiopharmaceuticals 99mTc-DTPA (370-555 MBq) or 99mTcMAG3 (185-350MBq), However their sensitivity could be different or vary in evaluation of hydronephrosis in view of sensitivity or physiology depending on T ½ value (half time of clearance) as a parameter to figure out the differences in biodistribution and clearance time of both radiopharmaceuticals 99mTc-DTPA and 99mTcMAG3 (A. Aktas et.al, 2006).

This study aimed to evaluate the T ½ values of common Radiopharmaceuticals (99mTc-DTPA and 99mTc-MAG3) in detection of Hydronephrosis in Sudan

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MATERIAL AND METHODS

A total of 100 patients were undergo kidney nuclear medicine investigations in two different nuclear medicine centers (RICK, Elnilen nuclear medicine centers) and divided into two groups Group one 50 undergo 99mTc-MAG3 nuclear medicine investigation in (RICK) hospital. Group two 50 patients undergo 99mTc-DTPA nuclear medicine investigation in Elnilin hospital. All patients in both groups were suffering from hydronephrosis either (obstructive or non-obstructive) and were injected within a specific protocol according to the specific radiopharmaceutical. The method that been used in administration of both radiopharmaceuticals (MAG3, DTPA) .

RESULTS

Results from the collected data presented (T ½) for the kidneys for both DTPA and MAG3, Age of hydronephrosis for patients, endemic cities by HyN, distribution of sample based on pathological condition of HyN and the gender involved by HyN)

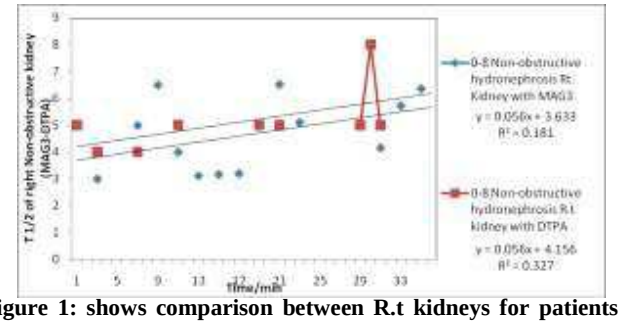

Figure 1: shows comparison between R.t kidneys for patients in sample whom been injected either by 99mTc-MAG and 99mTc-DTPA in time interval between (0-8min) which represents (non-obstructive hydronephrosis) cases in the sample.

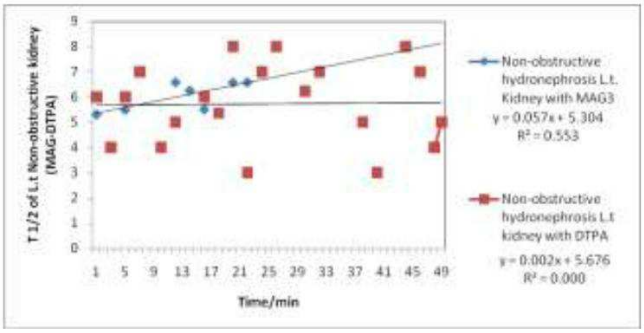

Figure 2: shows comparison between L.t kidneys for patients in sample whom been injected either by 99mTc-MAG and 99mTc-DTPA in time interval between (0-8min) which represents (non-obstructive hydronephrosis) cases in the sample.

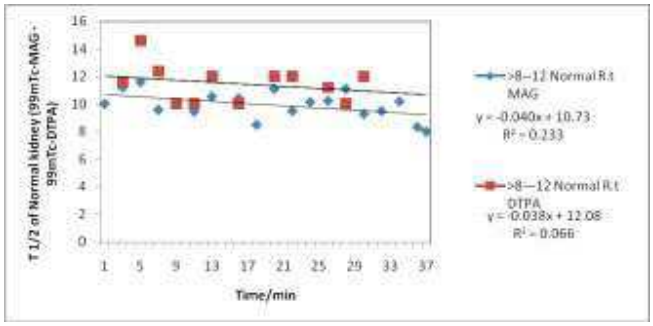

Figure 3: shows comparison between R.t kidneys for patients in sample whom been injected either by 99mTc-MAG and 99mTc-DTPA in time interval between (<8-12min) which represents (Normal R.t kidneys) cases in the sample.

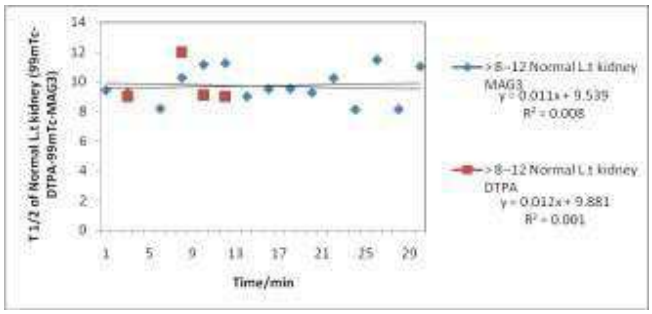

Figure 4: shows comparison between L.t kidneys for patients in sample whom been injected either by 99mTc-MAG and 99mTc-DTPA in time interval between (< 8-12min) which represents (Normal L.t kidneys) cases in the sample.

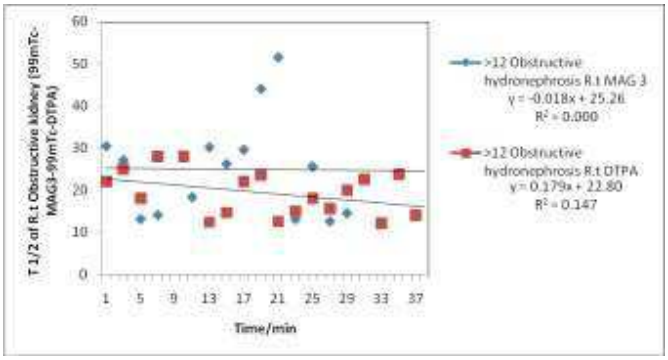

Figure 5: shows comparison between R.t kidneys for patients in sample whom been injected either by 99mTc-MAG and 99mTc-DTPA in time interval between (<12 min) which represents (obstructive hydronephrosis) cases in the sample.

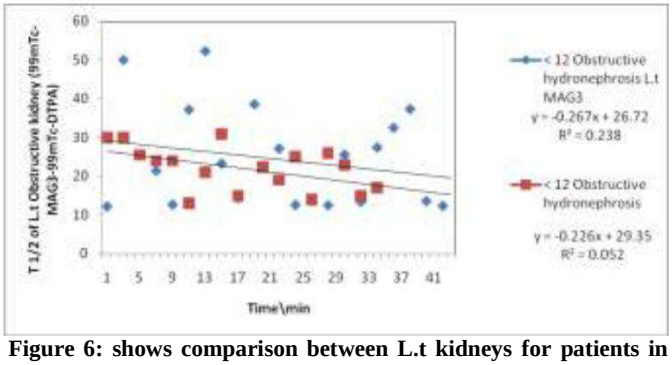

Figure 6: shows comparison between L.t kidneys for patients in sample whom been injected either by 99mTc-MAG and 99mTc-DTPA in time interval between (<12 min) which represents (obstructive hydronephrosis) cases in the sample.

Table 1: shows frequencies of different pathological statements in 200 kidneys divided according to site of kidney and type of radiopharmaceutical (99mTc-MAG3 OR 99mTc-DTPA).

Frequency % Kidne And radioph.	Non-obstructive hydronephrosis	Normal	Obstructive hydronephrosis
Right kidney 99mTc9-MAG3		9	7
Right kidney 99mTc8-DTPA		6	11
Left kidney 99mTc7-MAG3		7.5	10.5
Left kidney 99mTc4-DTPA		12.5	8.5

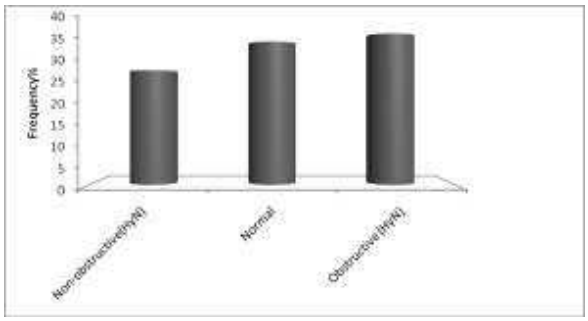

Figure 7: shows representation of the Pathological condition explaining frequencies (per kidney) in percentage.

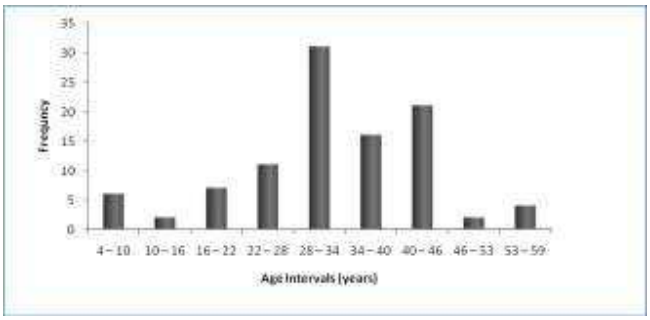

Figure 8: shows representation of the frequency of hydronephrosis cases in different age (years) intervals (classes).

DISCUSSION

The results of this study show the T ½ readings of the right kidney (obstructive and non-obstructive hydronephrosis) for the Patients injected with 99mTc-MAG3, its reveal that some patients who were suffering of Non-Ob\HyN having T ½ readings in the range of (0-8 min) as was truly diagnosed as Non-Ob\HyN kidney, and it took in consideration the normal T ½ readings in the range of (<8-12min) as was truly diagnosed as normal kidney, On the other hand also reveal that patients who were suffering of Ob\HyN having T ½ readings in the range of higher than 12 min as was truly diagnosed as Ob\HyN kidney, such ranges is in agreement with Fred A. et al, (2006) and also agree (in Ob/HyN cases) with François Jamar et al, (1992) as described in literature review, and disagree with Kletter and Nurnberger (1989) the T ½ readings of the Left kidney (obstructive and non-obstructive hydronephrosis) for the Patients injected with 99mTc-MAG3, reveal that some patients who were suffering of Non-Ob\HyN having T ½ readings in the range of (0-8 min) as was truly diagnosed as Non-Ob\HyN, the table took in consideration the normal T ½ readings in the range of (<8-12min) as was truly diagnosed as normal kidney, On the other hand also reveal that patients who were suffering of Ob\HyN having T ½ readings in the range of higher than 12 min , such ranges is in agreement with Fred A. et al, (2006) , (in Ob/HyN cases) with François Jamar et al, (1992) , and disagree with Kletter and Nurnberger (1989) ,the T ½ readings of the right kidney (obstructive and non-obstructive hydronephrosis) for the Patients injected with 99mTc-DTPA, reveal that some patients who were suffering of Non-Ob\HyN having T ½ readings in the range of (0-8 min) as was truly diagnosed as Non-Ob\HyN kidney, and the took in consideration the normal T ½ readings in the range of (<8-12min) as was truly diagnosed as normal kidney, On the other hand also reveal that patients who were suffering of Ob\HyN having T ½ readings in the range of higher than 12 min as was truly diagnosed as Ob\HyN kidney , such ranges is in agreement with Fred A. et al, (2006) , François Jamar et al, (1992) ,the T ½ readings of the Left kidney (obstructive and non-obstructive hydronephrosis) for the Patients injected with 99mTc-DTPA, reveal that some patients who were suffering of Non-Ob\HyN having T ½ readings in the range of (0-8 min) as was truly diagnosed as Non-Ob\HyN, On the other hand also reveal that patients who were suffering of Ob\HyN having T ½ readings in the range of higher than 12 min , such ranges is in agreement with Fred A. et al, (2006) , agree (in Ob/HyN cases) with François Jamar et al, (1992) , and disagree with Kletter and Nurnberger (1989) , comparison between T ½ readings of R.t. kidney in time interval (0-8) which represents Non-Obstructive hydronephrotic kidneys in both groups , which has been plotted in Figure1, such graph reveal that patients from both groups ,who truly diagnosed with Non-obstructive hydronephrotic kidney are falling in range of (0-8 min) ,the graphical plotting also shows comparison between T ½ readings in patients who suffering from Non-obstructive HyN ,Such comparison reveal that the relationship between the elapsed time of radiopharmaceutical and T ½ readings for patients injected with99mTc-MAG3 as follows: y = 0.056x + 3.633 , and for patients injected with 99mTc-DTPA as follows : y = 0.056x + 4.156 , where x refer to elapsed time and y refer to T ½ reading for the Rt.kidney with Non-Ob\HyN in both equations , from these equations we conclude that 99mTc-MAG3 is released more rapidly from kidney than 99mTc-DTPA, the researcher refer the reason to the differentiation of extra ctionefficiency for the radiopharmaceuticals (99mTc-MAG3, 99mTc-DTPA) because Non-obstructive hydronephrotic kidney is usually result from infection, vesicouretral reflux, or previous obstruction ,this will increase the pelvic pressure inside the kidney, and as 99mTc-MAG3's extraction efficiency is 95% mainly through tubuler

secretion and 99mTc-DTPA's extraction efficiency is 20% mainly through glumeuler filtration, the above causes of Non-Obstructive hydronephrosis will directly increase the tubuler rejection back to collecting tubules, which is in turn will reduce the T ½ value of 99mTc-DTPA, This result shows agreement with Fred A. et al, (2006), Adachi I et, al(1994), (Yusuke Inoue, et, al) (1999), KARAM, M, (2009) .comparison between T ½ readings patients who suffering from Non-obstructive HyN , Such comparison reveal that the relationship between the elapsed time of radiopharmaceutical and T ½ readings for patients injected with99mTc-MAG3 as follows: y = 0.057x + 5.304 , and for patients injected with 99mTc-DTPA as follows : y = 0.002x + 5.676 , where x refer to elapsed time and y refer to T ½ reading for the L.t.kidney with Non-Ob\HyN in both equations , from these equations we conclude that 99mTc-MAG3 is released more rapidly from kidney than 99mTc-DTPA, the researcher refer the reason to the differentiation of extraction efficiency for the radiopharmaceuticals (99mTc-MAG3, 99mTc-DTPA) because Non-obstructive hydronephrotic kidney is usually result from infection, vesicouretral reflux, or previous obstruction ,this will increase the pelvic pressure inside the kidney, and as 99mTc-MAG3's extraction efficiency is 95% mainly through tubuler

of Lt. kidney in time interval (0-8) which represents Non-secretion and 99mTc-DTPA's extraction efficiency is 20% mainly through glumeuler filtration, the above causes of Non-Obstructive hydronephrosis will directly increase the tubuler rejection back to collecting tubules, which is in turn will reduce the T ½ value of 99mTc-DTPA.this result also shows agreement with Fred A. et al, (2006) and Adachi I et, al(1994), (Yusuke Inoue, et, al) (1999), KARAM, M, (2009) .T ½ readings of R.t. kidney in time interval (<8-12) which represents the normal kidney readings in both groups , which has been plotted in Figure 3, such graph reveal that patients from both groups who truly diagnosed with Normal kidneys are falling in range of (<8-12 min), this result is showing agreement with Fred A. et al, (2006), (Taylor et al. (1994),and Adachi I et, al(1994) this result also gives statistical comparison between the two radiopharmaceuticals by mean of T readings during normal status of the kidney where as it reveal that 99mTc-MAG3 is excreted rapidly from kidney than 99mTc-DTPA according to the following equations, the relationship between the elapsed time of radiopharmaceutical and T ½ readings for patients injected with99mTc-MAG3 as follows: y = - 0.040x + 10.73 ,and for 99mTc-DTPA is: y = -0.038x + 12.08 and the researcher refer this result to the fact that 99mTc-MAG3 is more than twice higher in extraction efficiency than 99mTc-DTPA where as 99mTc-MAG3 is concentrating in kidney (which produce more satisfactory images) through two path ways, tubular secretion 90 - 95% and glomerular filtration 5-10%,while 99mTc-DTPA is approximately 20% (extraction fraction) bounded to plasma protein , and then tubular secretion renal agents are better because it gives low radiation exposure to the patient (rapid execration) and provide satisfactory images through (higher extraction efficiency) good biodistribution in renal parenchyma , showing agreement with Fred A. et al, (2006) ((Taylor et al. (1994) and Adachi I et, al(1994), (Yusuke Inoue, et, al) (1999), KARAM, M, (2009) . comparison between T ½ readings of L.t kidney in time interval (<8-12) which represents the normal kidney readings in both

groups, which has been plotted in Figure 4, such graph reveal that patients from both groups who truly diagnosed with Normal kidneys are falling in range of (<8-12 min), this result is showing agreement with Fred A. et al, (2006) ((Taylor et al. (1994) and Adachi I et, al(1994) this result also gives statistical comparison between the two radiopharmaceuticals by mean of T ½ readings during normal status of the kidney where as it reveal that 99mTc-MAG3 is excreted rapidly from kidney than 99mTc-DTPA according to the following equations, the relationship between the elapsed time of radiopharmaceutical and T ½ readings for patients injected with99mTc-MAG3 as follows: y = 0.011x + 9.539,and for 99mTc-DTPA is : y = 0.012x + 9.881, and the researcher refer this result to the fact that 99mTc-MAG3 is more than twice higher in extraction efficiency than 99mTc-DTPA whereas 99mTc-MAG3 is concentrating in kidney (which produce more satisfactory images) through two path ways , tubular secretion 90-95%,and glomerular filtration 5-10%,while 99mTc-DTPA is approximately 20% (extraction fraction) bounded to plasma protein , and then tubular secretion renal agents are better because it gives low radiation exposure to the patient (rapid execration) and provide satisfactory images through (higher extraction efficiency) good biodistribution in renal parenchyma , showing agreement with Fred A. et al, (2006) ((Taylor et al. (1994) and Adachi I et, al(1994), (Yusuke Inoue, et, al) (1999), KARAM, M, (2009) . comparison between T ½ readings of R.t kidney in time interval (12<min) which represents Obstructive hydronephrosis cases in both groups ,the data from has been plotted in Figure 5, such graph reveal that patients from both groups who truly diagnosed with Obstructive (HyN) are falling in range of (<12 min), this result is showing agreement with Fred A. et al, (2006) and François Jamar (1992) , the relationship between the elapsed time of radiopharmaceutical and T ½ readings for patients injected with99mTc-MAG3 as follows: y = 0.018x + 25.26 ,and for 99mTc-DTPA is : y = -0.179x + 22.80 , which reveal that 99mTc-MAG3 is also released rapidly from kidney than 99mTc-DTPA , and the researcher reveal this result to two reasons , the first one is that 99mTc-MAG3 has higher extraction efficiency than 99mTc-DTPA , and the second one that 99mTc-MAG3 has better response to fursmide (which is injected 15-20 min after administration of the radiopharmaceuticals) which is a strong diuretic compound to help the obstructive kidney to washout the radiopharmaceutical into urinary bladder, showing agreement with Fred A. et al, (2006) ((Taylor et al. (1994) and Adachi I et, al(1994), (Yusuke Inoue, et, al) (1999), KARAM, M, (2009),and Adil A. Al-Nahhas (1988) . comparison between T ½ readings of Lt. kidney in time interval (12<min) which represents Obstructive hydronephrosis cases in both groups ,the data from Figure 6, such graph reveal that patients from both groups (1,2) who truly diagnosed with Obstructive (HyN) are falling in range of (<12 min), this result is showing agreement with Fred A. et al, (2006) and François Jamar (1992), the relationship between the elapsed time of radiopharmaceutical and T ½ readings for patients injected with99mTc-MAG3 as follows y = -0.267x + 26.72, and for 99mTc-DTPA is : y = -0.226x + 29.35, which reveal that 99mTc-MAG3 is also released rapidly from kidney than 99mTc-DTPA , and the researcher reveal this result to two reasons , the first one is that 99mTc-MAG3 has higher extraction efficiency than 99mTc-DTPA , and the second one that 99mTc- MAG3 has better response to fursmide (which is injected 15-20 min after administration of the radiopharmaceuticals) which is a strong diuretic compound to help the obstructive kidney to washout the radiopharmaceutical into urinary bladder showing agreement with Fred A. et al, (2006) ((Taylor et al. (1994) and Adachi I et, al(1994), (Yusuke Inoue, et, al) (1999), KARAM, M, (2009) . Table 1 shows frequencies in percentage of different pathological statements in 200 kidneys contained in sample of 100 patients divided according to site of kidney and type of radiopharmaceutical (99mTc-MAG3 OR 99mTc-DTPA), and shows that Non-obstructive HyN is affecting the right kidney more than Lt. kidney, also shows that Obstructive (HyN) is also affecting the right kidney more than Lt. kidney.the Pathological condition explaining it's frequency (per Kidney) In the whole sample and it's frequencies per percentage ,which is plotted in (figure 7) , such graphical plotting shows that Obstuctive (HyN) is more frequent than (HyN) from Non-Obstructive causes , and this result is representing only the patients sample of the study (100 patient). the age's frequency in the whole sample of 100 patients arranged according to the age intervals which has been plotted in figure(8) ,such graphical plotting shows that by dividing a sample of 100 patients in age intervals starting from the class interval (4-10) as the lower limit and end with class interval (53-59) as an upper limit, the researcher found that hydronephrosis is affecting mostly the age class between (28-34) years which is appearing as the most frequent age class with such conditions in Sudan representing 31% of the cases and the “critical age for hydronephrosis in Sudan” , at the second class of age intervals comes the age class between (40-46) years representing 21% of hydronephrosis cases , third class of age interval which is most effected by hydronephrosis is the class interval between (34-40) years which is represents 16% of the sum of the cases , the age intervals (classes) (22 – 28) (4-10) , (10-16),(16-22),(46-53),and(53-59) are representing the minimum percentages of the sum of the cases(11%,6%,2%,7%,2%,4% respectively) which indicates that people in these age intervals are rarely affected by hydronephrosis . the frequencies of hydronephrosis in 100 patients arranged according to the cities, the study reveals that Khartoum city is the most endemic area by HyN which takes 62% of hydronephrosis cases, Madani 9% Kasala 6%, Al-Obayed, Dongola, AL-jazeera, AL-Nohood, Rabak, Sinnar, Al-Gadarif, Shandi and Al-nile Alazag are representing the lower endemic areas by HyN and they takes 5%, 1%, 3%, 1%, 1%, 1%, 4%, 2% and 5% respectively. The endemic could be due to high population in Khartoum and the lack of national nuclear medicine centers. The main expected causatives factor for HyN is the water pollution, as has been noted by UNESCO, (2005) that Khartoum state, Khartoum north and Omdurman were the most cities haves polluted ground water . the frequencies of hydronephrosis in Sudan of the whole sample of 100 patients arranged according to Gender Type, it shows that HyN with it's both types (Obstructive and Non-Obstructive) is affecting Males (54%) more than Females (46%) but there's no such big difference between the two genders and the percentage can be changed according to the risk factors in both genders (polluted water, hormone disturbance … etc

CONCLUSION

This sudy concluded that 99mTc-MAG3 showed lower T ½ readings in comparison with 99mTc-DTPA which indicates that 99mTc-MAG3 is cleared faster than 99mTc-DTPA in all the pathological conditions of hydronephrosis (Non-obstructive and Obstructive HyN) this conclusion is confirmed also by the comparison between the normal cases in the sample using the two radiopharmaceuticals (99mTc-MAG3 and 99mTc-DTPA) in which we can conclude that 99mTc-MAG3 is providing good Quality images beside low radiation dose to the patient and Nuclear Medicine technologist.

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