Radiolabelled cells and corpuscles In Nuclear Medicine

ESSAY

Submitted in partial fulfillment For Master Degree in Nuclear Medicine

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2006

ACKNOWLEDGEMENT

First and foremost , thanks GOD , the most beneficent and merciful . I wish to express my deep gratitude and respect, to *Prof .Dr.Abd Allah El Sayed El Taweel* , *Professor of nuclear medicine ,faculty of medicine , Cairo University* , For his close and gracious supervision with his great experience and scientific attitude that I owe a great deal, he guided this work all the time. I do hope that I can ever work under his guidance .

I offer my deepest gratitude and great thanks to *Prof . Dr. Saleh Abdo Mohamed Goda , Professor of Radio-isotopes , Faculty of medicine , Cairo University* ,for his faithful help and precious advices throughout the performance of this work . For him, no word of thanks or gratitude are sufficient .

Special thanks are due to *Dr. Amr Mohamed Amin* , *Lecturer of Nuclear medicine , Faculty of Medicine ,Cairo University* , for dedicating so much of his precious time and effort and his kindness , honest and constant guidance to complete this work .

Badr Abd Allah

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Abbreviations

ACD	Acid citrate dextrose
ACTH	Adrenocorticotrophic hormone
C^{14}	Carbon-14
Cr^{51}	Chromium -51
Cr^{+3}	Chromic ion
Cr^{+6}	Chromate
CT	Computed tomography
Cu-PTSM	Bis(thiosemicarbazone)
Cu^{64}	Copper 64
DFP	Diisopropyl flurophosphate
DVT	Deep venous thrombosis
ECD	Ethylcysteinate dimer
FAM	Functional anatomical maping
FDA	Food and drug administration
FDG	Flurodeoxy glucose
Fe^{51}	Iron-51
FPCIT	Fluoropropyl-2-beta-carbomethoxy-3-beta (4-iodophenyl) nortropanel
Ga^{67}	Gallium citrate 67
H^3	Tritiated Thymidin
HBSS	Hanks' balanced salt solution
Hct	Hematocrite
HIV	Human immunodeficiency virus
HMPAO	Hexamethyl propyleneamine oxim
IBD	Inflammatory bowel disease
In^{111}	Indium-111
ITP	Idiopathic thrombocytopenic purpura

Kev	Keloelectron volt
LE	Labeling efficiency
LPP	leukocyte poor plasma
MBq	mega Becquerel
mCi	Millicuri
MDP	methylenediphosphonate
MeV	Mega electron volt
MIBG	Meteiodobenzylguanidine
mm^3	Cubic millimeter
mSv	millisevert
P^{32}	Phosphorus-32
PET	Positron emission Tomography
PFS	Prolonged febrile syndrome
PNL	Polymorphnuclear leucocytes
PPP	Platelets –poor plasma
PRP	Platelets-rich plasma
PUI	platelet uptake index
RBCs	Red blood corpuscles
RCV	Red cell volume
ROI	Region of interest
S^{32}	Sulfer
SCE	sister chromatid exchanges
Sn^{IV}	Stannic ion
SPECT	single-photon emission computed tomography
SR	Spontaneously Released
$T_{1/2}$	Half life
TBV	Total blood volume

Tc^{99m}	Technetium-99 metastable
TTP	Thrombotic thrombocytopenic purpura
μCi	Micorocuri
μg	Micorogram
UV	Ultraviolet
WBCs	White blood cells

Introduction and aim of the work

Rationale and Background :

Circulating blood is an extraordinary complex mixture when blood is collected with an anticoagulant , the whole blood divides into a plasma component and a cellular component .

The cellular part is composed of three major portions , erythrocytes , leukocytes and platelets .

(Dacie and lewis ; 1984)

In nuclear medicine , the interest in hematology is present since 1938 when John Lawrence used P32 to treat myeloid leukemia , while George Hevessy used P32- labeled erythrocytes to measure blood volume in 1939.

(Price and Mcintyre ; 1984) .

Nuclear hematology has expanded aiming at study , diagnose and treatment of various hematological and non hematological disorders , with progressive improvement in the techniques for labeling blood cellular components , particularly platelets and leukocytes . These tests can give both quantitative and qualitative information

(Thakur ; 1990) .

The isotopic labels of the cellular elements of the blood are of two general types :

Cohort or pulse labels and random labels . The former is only available to the marrow precursors of a given cell type for a specific and limited length of time , while the random labels are radiopharmaceuticals that are applied to the circulating cells of the peripheral blood **(Thakur ; 1990)** .

The Aim of The work :

The aim of the work is to focus light on the methods and role of radiolabelled cells and corpuscles in nuclear medicine practice .

CHAPTER 1

BLOOD ELEMENTS AND THEIR DISORDERS

Blood elements and their disorders

Radiolabelled cells and corpuscles used in nuclear medicine include ; red blood cells , platelet, white blood cells , as well as lymphocytes.

Red blood cells :

They are rounded , non nucleated , biconcave discs , of 7.5 microns diameter and 1.9 microns of thickness at the periphery and 1.1 microns of their centers . They are greenish yellow in colour due to presence of hemoglobin . Their number varies from 5 - 5.5 million per cubic millimeter in males and 4.5 - 5.5 million per cubic millimeter in females . They have a limited life span ; 120 days .

The functions of RBCs are ; gaseous exchanges through their biconcave surfaces , exchange of carbon dioxide and oxygen through their cell membrane , the main function of RBCs is to enclose hemoglobin ; which combines easily with oxygen to form oxyhemoglobin which goes to the tissues to supply them with oxygen . Hemoglobin also plays a role in controlling the hydrogen ion concentration of the blood . Hemoglobin can only do these functions when it is present inside the RBCs . Also , RBCs are rich in carbonic anhydrase enzyme which plays an important role in the transportation of carbon dioxide from the tissues to the lungs **(Surgenor ; 1974)** .

Erythrocyte disorders are traditionally divided into two groups: *Anemia* and *polycythemia* . Although this division is based on the presence of too few red cells (erythrocytopenia) and too many red cells

(erythrocytosis) respectively . Anemia is functionally best characterized by a hemoglobin concentration below normal whereas polycythemia is characterized by a hematocrite above normal .This use of two different erythroid parameters in the characterization of anemia and polycythemia is actually based on clinical considerations . Anemia is a disorder in which the patient suffers from tissue hypoxia, the consequence of a low oxygen carrying capacity of the blood . Polycythemia however,is a disorder in which the clinical manifestations are related to increased whole blood viscosity and increased blood volume , both consequences of a high hematocrite . **(Allan ; 1991)** .

- Anemia is classified into relative and absolute

Relative anemia which is either due to pregnancy , nutritional deficiency or splenomegally.

Absolute anemia caused by either decreased red cell production or increased erythrocyte destruction or loss.

Decreased red cell production which is due to :

- Disturbance of proliferation and differentiation of hemopoietic stem cells as in aplastic anemia and myeloplastic anemia .
- Disturbance of proliferation and differentiation of erythroid progenitor or precursor cells as in pure red cell aplasia , anemia of chronic renal failure and anemia of endocrine disorders .
- Disturbance of D NA synthesis (megaloblastic anemia) as in vitamin B_{12} deficiency and folic acid deficiency .

- Disturbance of hemoglobin synthesis (Hypochromic anemia) as in iron deficiency and thalassemia .
- Unknown or multiple mechanisms as in anemia of chronic disorders and anemia associated with nutritional deficiency .

Increased erythrocyte destruction or loss ;which is due to :

Intrinsic abnormality ; which include :

- Membrane defect as in hereditary spherocytosis .
- Enzyme deficiency as in glucose 6-phosphate dehydrogenase deficiency and porphyria .
- Globin abnormality (hemoglobinopathy) as in sickle cell disease and related disorder .

Extrinsic abnormality ; which is due to :

- Mechanical ; as in Marsh hemoglobinuria , sports anemia and traumatic cardiac hemolytic anemia .
- Chemical or physical ; as in hemolytic anemia due to chemical and physical agents .
- Infections ; as in hemolytic anemia due to infections with micro organism .
- Antibody mediated ; as in acquired hemolytic anemia due to warm-reacting auto-antibodies and alloimmune hemolytic disease of newborn.
- Hyperactivity of the monocyte-macrophage system ; as in hypersplenism .
- Blood loss ; as in acute blood loss anemia .

(Allan ; 1991).

- **Polycythemia:**

The clinical and laboratory features of patients with Polycythemia depends primarily on the etiology and pathogenesis of the underlying disorder .However, the production and presence of an increased number of red cells are associated with certain general effects on *marrow function , blood viscosity , and blood volume* .

Under normal conditions , the rate of red cell production is adjusted to maintain the red cell mass at about 30ml/kg of body weight. Since the life span of the red cells in Polycythemia is normal .The morphology and volume of the marrow are only moderately altered in Polycythemia in comparison with the changes observed in some types of anemia , in which the rate of red cell production may be 6 to 10 times normal .

Viscosity and blood volume:A sustained increase in red cell production will lead to an increase in both hematocrite and blood volume .The associated increases in viscosity and vascular volume are responsible for many of the signs and symptoms of Polycythemia **(Dintenfass ;1966)**.Thromboses are common in Polycythemia Vera , but they also occur in erythrocytosis when aggravated by plasma loss (e.g. dehydration) or by alveolar hypoventilation **(Monge ;1966)** .

Polycythemia is mainly classified into relative and absolute :

Relative Polycythemia which is either due to dehydration or spurious erythrocytosis (stress or smoker) **(Humphrey ; 1980)** .

Absolute Polycythemia with an increased red cell mass can be classified as *primary* and *secondary* .

- *Primary Polycythemia* ; is a purposeless , idiopathic hyperplasia of pleuripotential stem cells causing pancytosis (Polycythemia Vera) or rarely essential erythremia .
- *Secondary Polycythemia* can be classified as : appropriate and inappropriate .

Secondary appropriate Polycythemia ; should perhaps not be considered a hematologic disorder , since it represents a physiologic compensatory response to tissue hypoxia as in high altitude and cardiopulmonary disorders .

Secondary inappropriate Polycythemia ; *is generally believed to be caused by an inappropriate secretion of erythropoietin by cysts or tumors* **(Erslev and Caro ; 1984)** .

White blood cells :

They are colourless ,true nucleated cells , contain no hemoglobin and contain all the cell organoids and the cell inclusions . They vary in number from 4000 to 11000 per cubic millimeter . At birth the total leucocytic count is about 16000 per cubic millimeter.

(Cruickshank and Alexander ;1970).

According to the presence of granules leucocytes are classified into *granular leucocytes* (the neutrophils , eosinophils and basophils) and *non granular leucocytes* (the lymphocytes and monocytes) .

Granular leucocytes :

- Neutrophils or (polymorph nuclear leucocyte)

Constitute 60 - 70% of total leucocytes , with life span of 4 days . Their functions are : Phagocytic to the micro-organisms in the tissues outside the