Heath Effects Sequence of Meet Halfa Radiological Accident After Twelve Years

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ABSTRACT

The accident of Meet-Halfa developed consequent upon the loss of an industrial gamma radiography source. The source was found by a farmer resident of Meet-Halfa who took it to his house occupied by his family. The sequence of events developed over a period of seven weeks from the time the source was found on May 5, 2000, till the day of its retrieval from the house by the national authorities on June 26. The protracted exposure patterns of the family members during the period of source possession are not precisely known, however these exposures resulted in two fatalities, clinical forms of bone marrow depression, and several skin burns of different severities. The recent sequences of the accident is as follows:-
The three survived siblings married and get good children. That mean there is no hereditary stochastic effects. The sister died at 2007 with 72 years old with senility and no specific disease. The youngest daughter amputate the left thumb and index fingers at 2001. The elder son amputate the terminal phalanx of the right thumb at 2009. The youngest daughter amputate the right index finger at 2009. The elder son graft the burn at the lower right quadrant of the abdomen for more than 20 times (3 of them were in the Mansheat Al-Bakry Millitary Hospital), but there is residual of burn untill now. Sever abdominal hernia in the elder son due to necroses in the right quadrant abdominal muscles. Grafting for these muscles occur but failed.

INTRODUCTION

Nature of the Accident

The accident of Meet-Halfa developed consequent upon the loss of an industrial gamma radiography source. The source was found by a farmer resident of Meet-Halfa who took it to his house occupied by his family . The sequence of events developed over a period of seven weeks from the time the source was found on May 5, 2000, till the day of its retrieval from the house by the national authorities on June 26.

The protracted exposure patterns of the family members during the period of source possession are not precisely known, however these exposures resulted in two fatalities, clinical forms of bone marrow depression, and several skin burns of different severities.

CHRONOLOGY OF EVENTS

Possession of the Radiological Source.

On May 5, a resident from Meet-Halfa village found an industrial gamma radiography source that had been lost sometime before from an operator working for pipe welding testing company. Ignorant of the real nature of the strange looking metal object, the man took the source home where he lived with his wife, sister, two sons and two daughters. All seven

members of the family were fascinated by the object and firmly believed it was of precious metal.

During the weeks that followed, the source was handled by the family members with varying frequencies and durations. It was placed in different places for various periods, mainly in a cardboard box on top of a closet in the utility room. The family members were subject to protracted radiation exposures of different intensities. Determination of the nature, magnitude, extent and duration of the radiation exposure involved in such circumstances is very difficult to achieve.

Development of Events

On June 5, a message was received at the Infectious Disease office at the Ministry of Health in Cairo, from the Public Health Department at Qaluobiya; reporting the death of a nine years old child from Meet- Halfa village. The clinical condition prior to death was that of marked bone marrow failure and extensive inflammatory skin lesions. No indication of the exact diagnosis was given.

On June 10, a fact-finding mission from the Ministry of Health discovered four cases with similar signs and symptoms among family members of the deceased boy. The diagnosis of an inflammatory or viral cutaneous lesion associated with bone marrow depression was coined to the condition. All family members were admitted to Imbaba Fever hospital for observation.

On June 16, the father died from bone marrow failure associated with extensive inflammatory skin lesions. The remaining members of the family were further transferred to Abassiah Fever hospital for further studies. All laboratory investigations related to inflammatory or viral conditions of the skin proved negative.

Response of National Authorities.

On June 25, a task group from the Ministry of public Health was sent to Meet Halfa on a fact finding mission. The results of the mission revealed high radiation levels around the family house. The responsible authorities were immediately notified.

On June 26, experts from the Division of Chemical Warfare (armed forces) and from the Atomic Energy Authority (AEA) carried out detailed radiological survey of the family house and its surroundings at Meet-Halfa. A radiological industrial source was eventually found in a cardboard box above the closet in the utility room.

The source was controlled, retrieved, contained in a suitable lead container and transported under protective guidance to the Atomic Energy Authority laboratories at Inchas where it was placed in one of the hot cells. A radiological survey was further conducted at Meet-Halfa, and the village was declared free of high radiation levels.

On June 26, it became evident that the death of the younger son and the father, and the clinical conditions of the remaining members of the family were caused by the radiation exposures they received during the time they lived in the house in possession of the source from May 5 until June 10, the time they were admitted to Imbaba Fever hospital. on June 26, when the diagnosis of radiation effects was ascertained, the female members of the family were transferred to Naser Medical Institute to be placed under direct supervision of an expert

group from the National Cancer Institute. The elder boy of the family, being an army recruit was transferred to Maadi Military Hospital.

The source was Iridium 192. The half life of Iridium192 is 74 days. Calculating the decay process, the source activity would be 31.5 Curies on May 5 the day the source was found and became in possession of the family. On June 26, the day the source was retrieved, its activity would be 19.34 Curies. Iridium192 has a complicated gamma spectrum from 0.136 –1.062 MeV. The specific gamma ray emission (Gamma Factor) of Iridium192 is 0.13 mSv per hour at one meter per Giga Bq (10^9 Bq). (150 – 93 mSv per hour at one meter).

The Exposed Groups.

Family members. Thesewere in possession of the source from May 5, to June 10. This included the father (Sixty years), the wife (fifty years), the sister (Sixty five years), the older son (twenty two years), the younger son (nine years), the older daughter (seventeen years), and the younger daughter (thirteen years). The younger son died on June 5, and the father died on June 16.

According to detailed investigation revealed that the number of family associates including neighbors and relatives does not exceed 50 individuals. Because of the prudence and discretion of the farmer, very few associates knew of the radiological source hidden in the cardboard box on top of that closet in the utility room

Radiation Dose Estimates of Exposed Groups.

Using the Gamma Factor of 0.13 mSv per hour at one meter for one Giga Bq and the activity of the source of 31.5 Ci on May 5, and 19.34 Ci on June 26; the effective doses were 151 mSv per hr at one meter and 93 mSv per hr at on meter on the dates indicated respectively.

The exposures were protracted and subject to several known variables including frequency, mode, duration and exact dose rate at time of exposure. This particular situation renders precise dose estimates to the exposed groups very difficult to achieve and subject to a wide margin of error.

Dose Estimates to Family Members. Dose estimates to this members family would be based on the type and severity of the biological effects incurred to each individual. The biological indicators used for dosimetric purposes would include such criteria as degree and extent of skin burns, changes of peripheral blood cells, severity of bone marrow affection, gastrointestinal disturbances and cytogenetic findings.

Taking into account the dose rate on May 5, and on June 26; and considering the acute effects acquired by the members of the family, it would be rational to postulate a cumulative dose of 7.5 – 8 Gy to the father, and a cumulative dose of 5.5-6 Gy to the younger son. Both died from bone marrow failure, severe skin burns and gastrointestinal manifestations.

Cumulative doses to the wife and sister approximate to about 3.5-4Gy; and to the older son would be about 4.5 Gy localized to the lower right quadrant of the abdomen. The cumulative dose to the elder daughter reached 4 Gy to the whole body affecting bone marrow

deposits. The cumulative dose to the younger daughter is of the same magnitude, with characteristic localization to the skin of both hands, Rt. Knee and Rt. thigh.

Dose estimates to radiation survey groups. These include a total of 70-100 individuals. These groups were exposed to low level radiation during the survey operations. Personal dose-meters carried by some individuals during the survey procedures gave readings between 1-15 mSv.

Dose estimates to family associates. As previously mentioned, the number of family associates was about 50 individuals. The exposure doses to this group would range between 0.5 and 5 mSv.

Radiation Dose Estimates to Exposed Groups

(Protracted Exposure)

A- Family Members

Members	Dose (Gy)	Members	Dose (Gy)
Father	7.5-8 Total Body	Sister	3.5 – 4 Total Body
Younger Son	5-6 Total Body	Wife	3.5 – 4 Total Body
Elder Son	3.5 – 4 Localized	Younger Daughter	3.5 – 4 Localized
		Elder Daughter	3.5 – 4 Total Body

B- Radiation Survey Groups

Number	Dose (mSv)
70-100 individuals	1-15 mSv

C- Family Associates

Number	Dose (mSv)
50 individuals	1- 5 mSv

MEDICAL ASPECTS.

The Early Phase.

The essential features of this case study are the radiation effects induced after accidental protracted overexposure from cumulative doses acquired over five to six weeks. The determination of the nature, magnitude, extent, duration and frequency of the exposure in this case is very difficult to achieve.

The prodromal signs and symptoms reported by the members of the family were generalized malaise, fatigue, and skin ulceration. The early laboratory investigations indicated decreased peripheral blood counts, signs of bone marrow depression and infected skin lesions. The diagnosis of viral or infective cutaneous condition was suggested.

The younger son died on the June 5, followed by the father's death on June 16. The death in both cases was attributed to bone marrow aplasia, severe infected skin lesions, and signs of gastrointestinal disturbance. The cause of death from acute radiation injury induced by accidental protracted overexposure was ascertained only after the Iridium192 source was retrieved from the family house on June 26. The clinical manifestations of the remaining five members of the family were finally diagnosed as being radiation induced. In order to provide adequate medical care for the five members of the family, the sister, the wife and the two daughters were transferred to Naser Medical Institute Hospital. On June 26, and the elder son was admitted at Maadi Military Hospital.

Clinical and Laboratory Investigations.

At both medical facilities, similar clinical investigations were performed, and the same treatment protocols were adopted. The clinical and laboratory investigations comprised complete clinical examination including the skin, hair, oral cavity and genitals, X-Ray of chest, electrocardiogram, abdominal ultrasonic, complete total and differential blood count, liver and kidney function tests, blood chemistry, bone marrow examination and cytogenetic studies of blood cells.

Bone marrow: All bone marrow examinations for the five patients showed evidence of bone marrow hypocellularity of all cell lines, particularly evident in the myeloid, lymphocyte, and megakaryocyte cell lines. Differences in severity were observed among the patients.

Hematological data. Early laboratory finding after admission revealed different degrees of leucopaenia, anaemia and decreased platelet counts. During hospitalization blood counts were performed daily for the first week, every other day during the second week and twice during the third week . This was followed by weekly counts during the outpatient follow up. The data for peripheral blood counts for each patient at specific selected times over two months covering the period of hospitalization from June 26 to July 20, and extending as out patient follow up till August 25, are given in figures 1-5 (a,b,c).

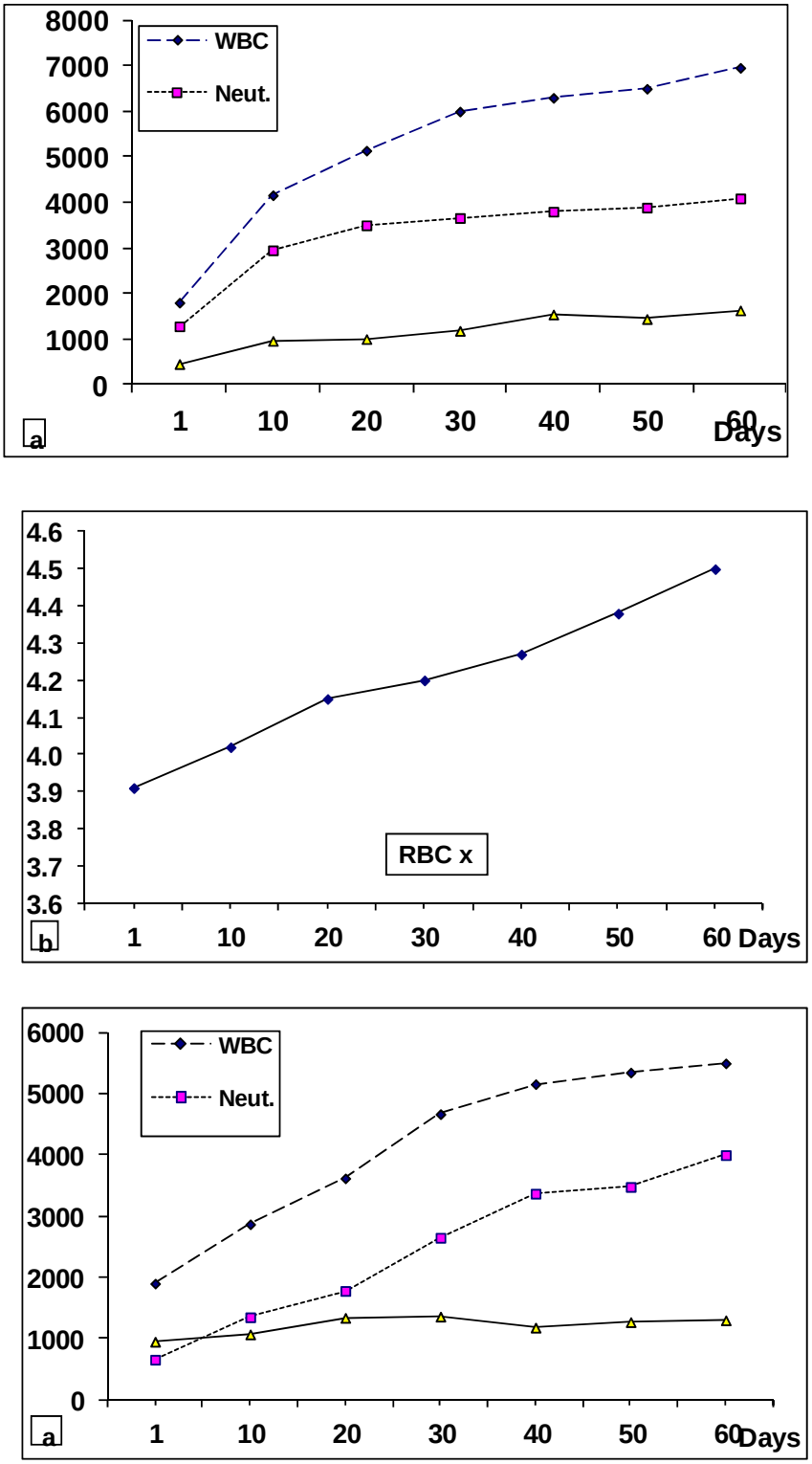


Figure 1 (a,b,c) show data for haematological findings (total WBCs, Neutrophiles, Lymphocytes, RBCs and Platelet counts) for the sister, over a period of sixty days

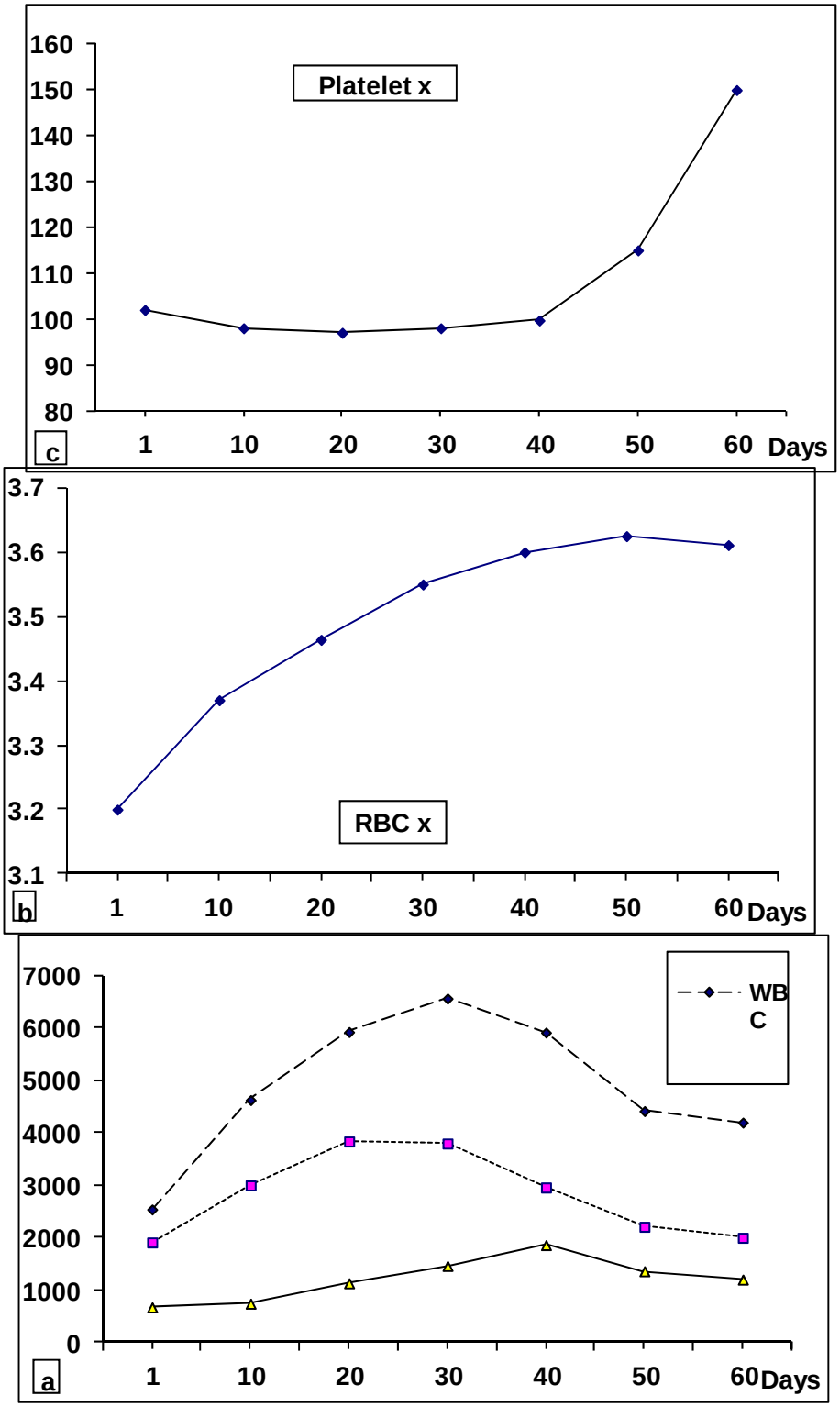


Figure 2 (a,b,c) show data for haematological findings (total WBCs, Neutrophiles, Lymphocytes, RBCs and Platelet counts) for the wife, over a period of sixty days.

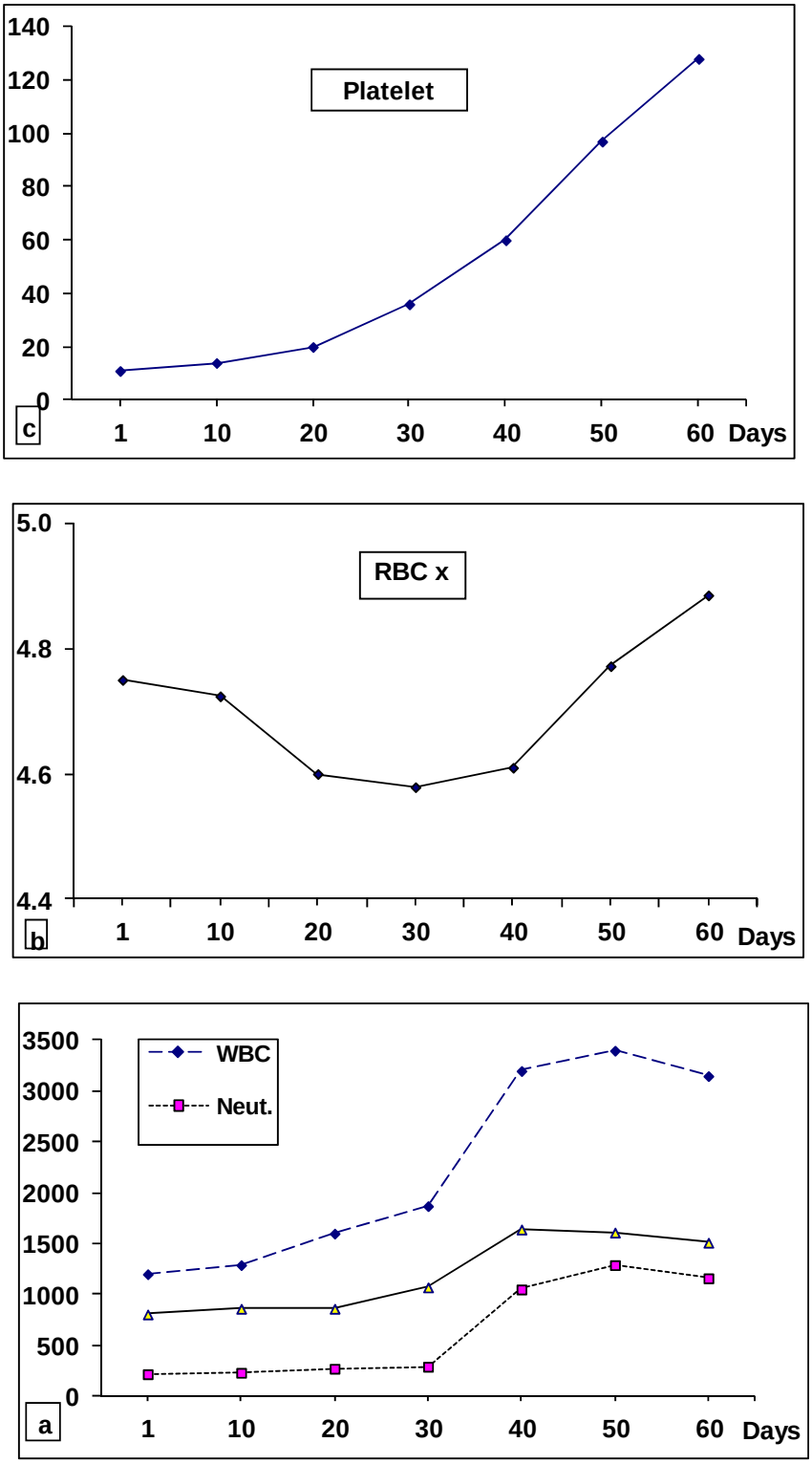


Figure 3 (a,b,c) show data for haematological findings (total WBCs, Neutrophiles, Lymphocytes, RBCs and Platelet counts) for <u>elder son</u>, over a period of sixty days

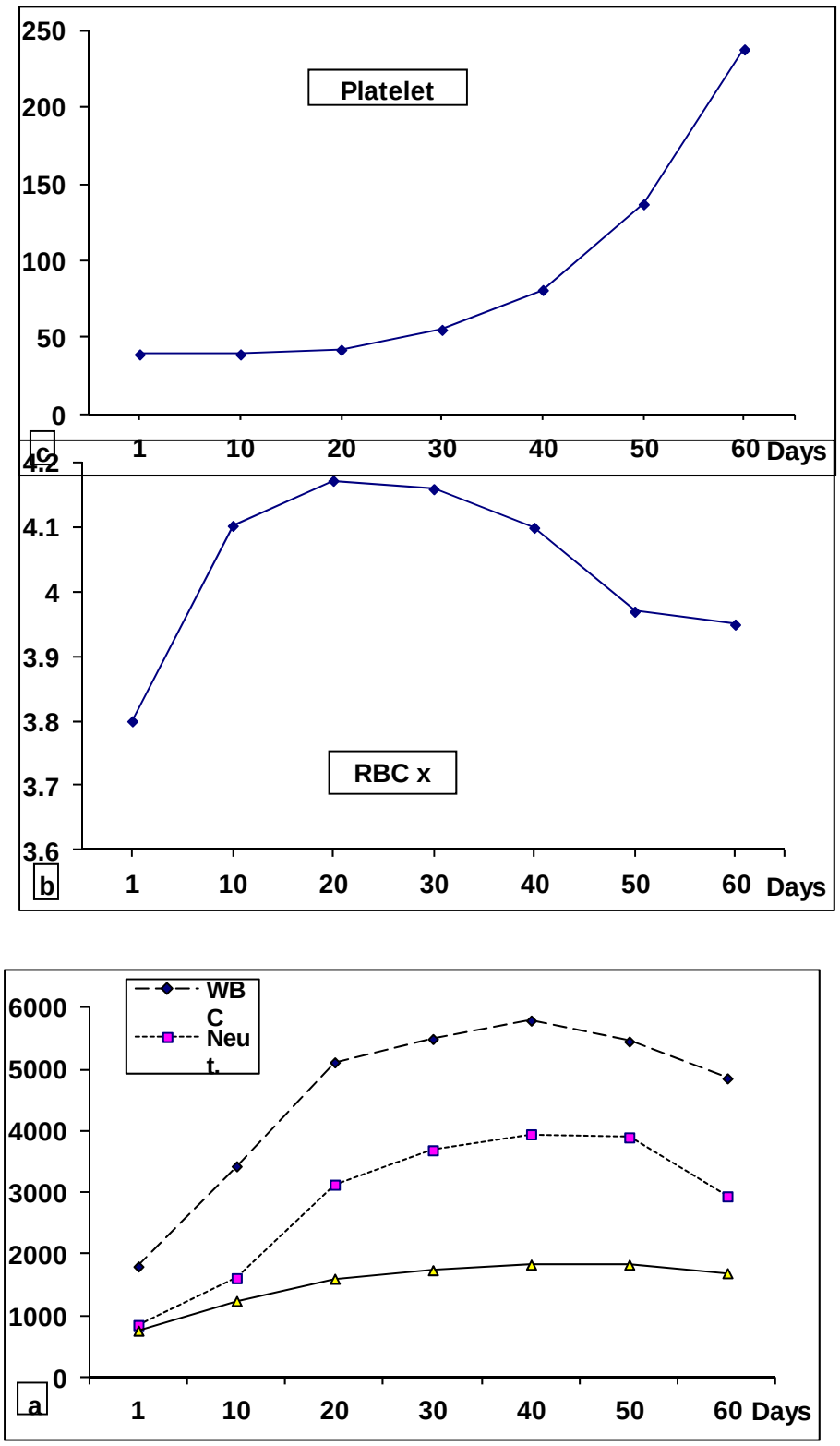


Figure 4 (a,b,c) show data for haematological findings (total WBCs, Neutrophiles, Lymphocytes, RBCs and Platelet counts) for elder daughter, over a period of sixty days.

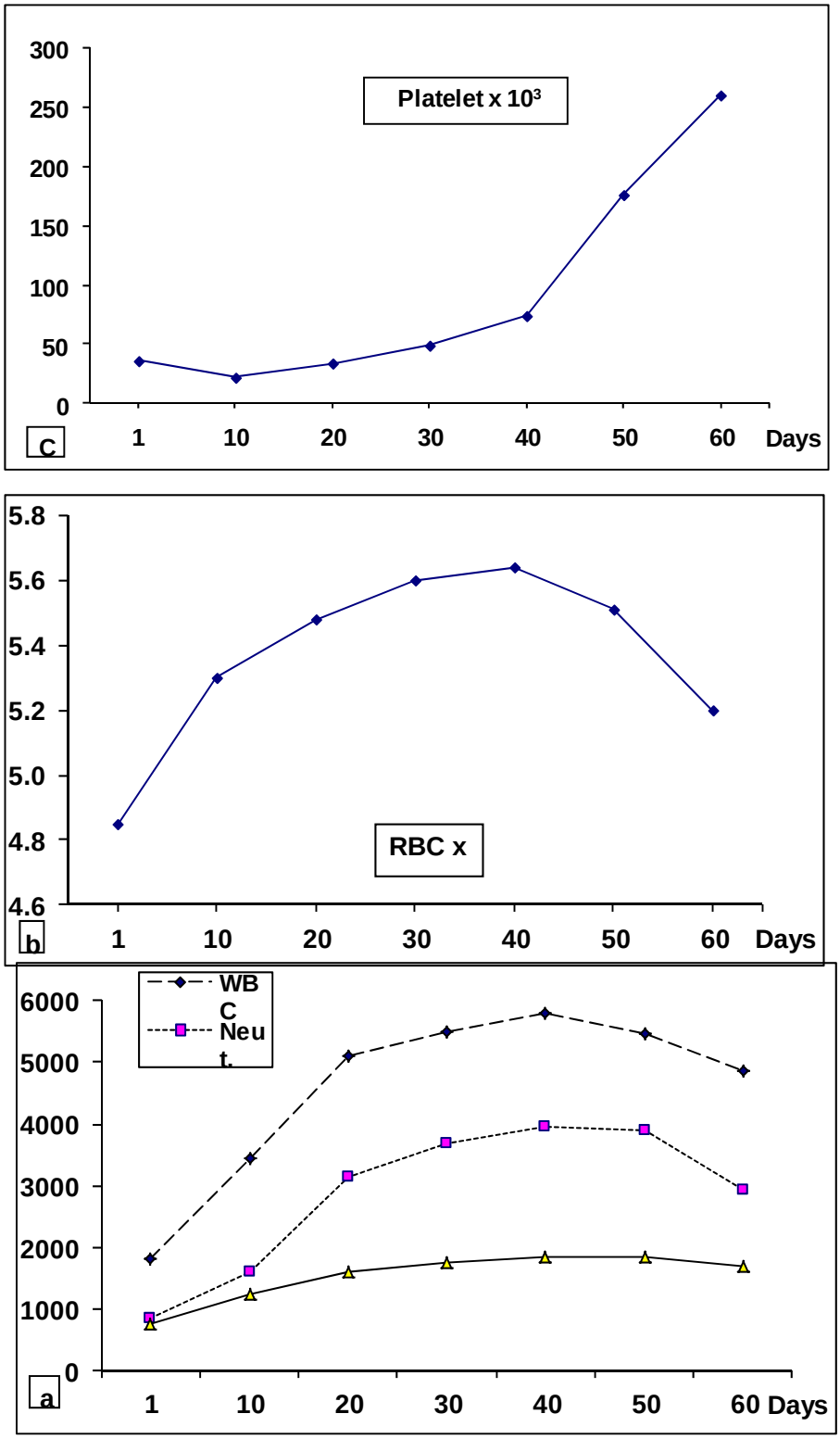
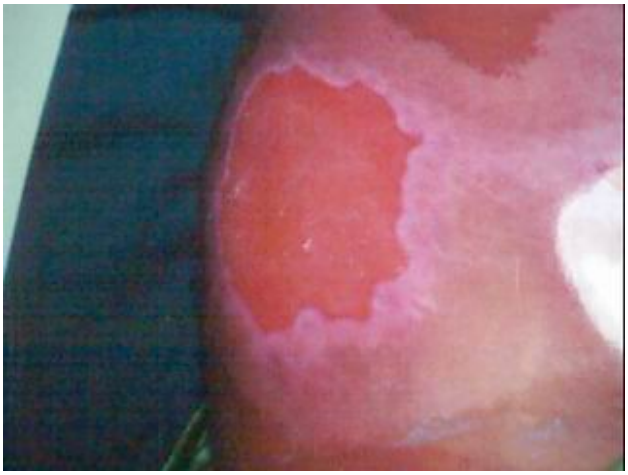
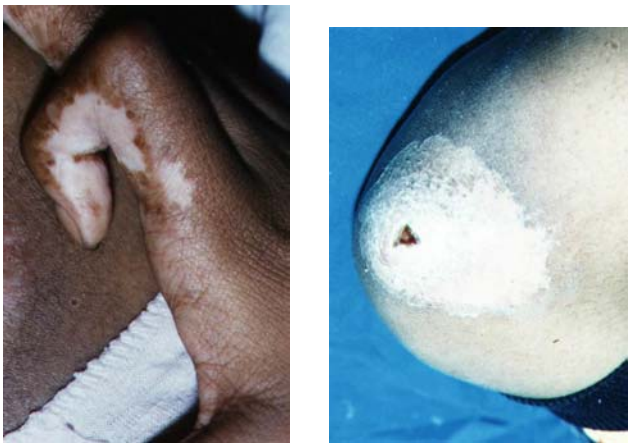


Figure 5 (a,b,c) show data for haematological findings (total WBCs, Neutrophiles, Lymphocytes, RBCs and Platelet counts) for younger daughter, over a period of sixty days.

Skin burns. The elder son suffered extensive skin burns of varying degrees affecting the lower right quadrant of the abdomen and extending laterally. The thumb and index finger showed evidence of healing radiation ulcers. Severe stomatitis and rash were reported. The younger daughter showed severe burns and contractures of both hands mainly involving the palms, index and thumb of left and right hands, deep localized ulcer of right knee, and deep localized ulcer at upper outer aspect of the right thigh. The wife showed a healing ulcer at the distal end of the Rt. Index finger. No other significant findings were observed. Photographs of skin lesions are shown.





Cytogenetic studies. Reports of cytogenetic studies of blood cells for all five patients indicated no evidence of any abnormality. Such results appeared questionable, since it was expected that some radiation induced dicentrics or other abnormalities would appear in the cytogenetic examinations. However, in this situation, the accidental protracted exposure may have resulted in non uniform doses to only a portion of the body from low LET radiation from a point source. The lymphocytes present in the radiation field received a radiation dose. Exposed and non-exposed lymphocytes became mixed as blood circulates. If only a small portion of the body was exposed (e.g. fingers, extremity or localized part of body, the number of lymphocytes receiving radiation damage are too few to provide a reasonable probability of detecting cytogenetic evidence to be used for dosimetric purposes.

Psychological Implications.

Various degrees of psychological manifestations were evident during the events of the accident. The main causes of these manifestations were absence of exact credible information about the accident, ignorance of the nature of radiation effects, and uncertainties regarding the chances of recovery and the consequences of exposure and the delayed effects. These psychological patterns affected mainly the surviving members of the family. However, several village residents were concerned about radioactive pollution, and anxious about contagious possibilities. These psychological implications were an outstanding feature during the early

phases of the accident events. The remaining psychological symptoms concerned the surviving members of the family regarding the chances of total recovery, and means of support after the father's death.

Medical Management.

The treatment protocols adopted for the five patients were essentially similar, however, certain medications were used according to specific patient needs. The main lines of medical management included the following:

- Patient isolation in laminar air flow tent.
- Administration of excellent hygiene with daily baths,
- Maintaining high quality nursing-mouth and respiratory care.
- Complete control of portals of infection.
- Well balanced food and fluid intake.
- Maintain proper electrolyte balance
- Administration of Granulocyte Colony Stimulating Factor (Neopogen 10 microgram / kg/day)
- Liberal use of Antibiotics (ceprafloxacid 500mg/12hrs) or (Augmentine 650 mg/8hrs)
- Platelet transfusion for the elder daughter.
- Hormonal treatment to control menstruation for the elder daughter.
- Multivitamins.
- Antifungal and Antimicotic drugs when needed
- Attending to the skin lesions with suitable medication and dressings.
- Skin grafting for the elder boy which failed on two trials. A third trial is contemplated.

RECENT SEQUENCES

1- **The three survived siblings married and get good children. That mean there is no hereditary stochastic effects.**
2- **The sister died at 2007 with 72 years old with** senility **and no specific disease.**
3- **The youngest daughter amputate the left thumb and index fingers at 2001.**
4- **The elder son amputate the terminal phalanx of the right thumb at 2009.**
5- **The youngest daughter amputate the right index finger at 2009.**
6- **The elder son graft the burn at the lower right quadrant of the abdomen for more than 20 times (3 of them were in the Mansheat Al-Bakry Millitary Hospital), but there is residual of burn untill now.**
7- **Sever abdominal hernia in the elder son due to necroses in the right quadrant abdominal muscles. Grafting for these muscles occur but failed.**

The following photos are for the elder son showing the remaining abdominal ulcer in the lower right quadrant of the abdomen; sever abdominal hernia and the right thumb after amputation of the terminal phalanx.

LESSONS LEARNED.

Any radiation accident will add knowledge and experience. Accident from lost, stolen or neglected sources are particularly special because the radiation exposure patterns of the individuals involved and the scenario of the accident are always different.

The accident of Meet-Halfa provide several aspects and defines generic lessons to be learned by the regulatory authorities, source operators, manufacturers and all individuals responsible for the safety of radiation sources. Some of these important aspects that should be considered as lessons learned are: Proper implementation of the codes of practice, minimizing the probability of human error, by repeated educational training programmes, minimizing the probability of source malfunction by performance of repeated maintenance, stringent supervision over the logistics involved in importing, licensing, transportation and – recording of sources and formulation of a proper system for dealing with spent sources.

REFERENCES

(1) R. A. Allen et al., United Kingdom Atomic Energy Authority, Radioisotope Data, (1961).
(2) International Atomic Energy Agency – Technical Reports series No.260, (1986).
(3) The Radiological Accident in Goiana, IAEA, (1988).
(4) The Radiological Accident in San Salvador, IAEA, (1990).
(5) The Medical Basis of Radiation Accident Preparedness II, Editors Robert C. Ricks and Shirley Fry (1990).
(6) The Medical Basis of Radiation Accident Preparedness III, 1991 Editors Robert C. Ricks, Mary Ellen Berger and a Frederick. O, Hara (1991).
(7) International Atomic Energy Agency, Manual on Gamma Radiography, (1992).
(8) Lessons learned from Accidents in Industrial Radiography – IAEA – Safety Report Series, No.7, (1998).
(9) International Atomic Energy Agency, Radiation Protection and Safety in Industrial Radiography, Safety Report Series, No.13, (1999).
(10) Major Radiation Accidents Worldwide (1944-2000) Radiation Accident Registries, REAC/TS, (2000).
(11) Atomic Energy Authority Report, Cairo, Egypt, (July 2000).
(12) Ministry of Health Report, Cairo, Egypt, (July 2000).