

Lymphoscintigraphic Evaluation of Lymphatic Function in both Men and Women for early Diagnosis and Management of Filariasis and Congenital Lymphatic Edema

¹K. Jagadeesan, ²R. Tamilselvi, ³T. M. R. Panicker

¹Chief Surgeon, K. J. Hospital & Chairman, K. J. Research Foundation

² Professor, Electronics and Communication Engineering Sethu Institute of Technology

³ Prof. of Radiological Physics & Dean of Faculty, K. J. Research Foundation

ABSTRACT

Lymphedema is caused by an abnormality of the lymphatic system leading to excessive build up of tissue fluid that forms lymph, known as interstitial fluid. Stagnant lymph fluid contains protein and cell debris that causes swelling of affected tissues. Lymph is responsible for transporting essential immune chemicals and cells. Left untreated, lymphedema leads to chronic inflammation, infection and hardening of the skin that, in turn, results in further lymph vessel damage and distortion of the shape of affected body parts. Evaluation of lymphatic flow using radio nuclide tracer by scintigraphy is a standard procedure for obtaining information about the morphology and physiology of lymphatics and their abnormalities like obstruction, dilation and other flow disorder characteristics. One of the main medical applications of this instrument would be in the early diagnosis and management of prevalent diseases such as filariasis and congenital lymphatic edema.

The system developed facilitates simultaneous lymphatic flow measurement at different locations in the limb after the injection of radioactive tracer (Tc99m, 140 KeV). Typically, seven miniature scintillation detectors are placed at specified locations on the limbs, which detect the activity at various locations on the body; the health of the lymphatic flow is inferred. This paper highlights the design features of the system and the associated software for medical application.

Key Words: Flow Assessment, Counts, Flow Velocity, Scatter plot, Histogram Analysis.

Introduction

Conventional procedure involves the use of a radioactive tracer like Tc-99m tagged with HSA (particle size 0.2 & 0.5 micron), 0.5 to 1.0 mCi subcutaneously injected into the web space of the limbs and subsequent monitoring of flow by gamma camera imaging. The equipment normally used includes scintillation camera along with the computer based imaging device for data acquisition and is large in size in addition to being prohibitively costly. Medical teams are needed to set up field camps in rural or disease-prone areas where a large number of people

could be screened and an initial diagnosis done. The requirement for such a purpose would be for a small system incorporating micro radiation detectors placed at anatomical points with almost all the functions of lab based equipment but ideally suited for field operation. One of the main medical applications of this instrument would be in the early diagnosis and management of prevalent diseases such as filariasis and congenital lymphatic oedema. It should have a complete medical data base of patients and quick on the spot data archival and presentation so that an initial screening of patients could be done effectively and decisions could be taken for referring serious cases to hospitals for further investigation management and follow-up.[1]

A prototype of the instrument was earlier tested with patients and volunteers and the data compared with simultaneous measurements done with the gamma camera at the Department of Nuclear Medicine, K. J. Hospital, Chennai.

Address for correspondence

Dr. K.Jagadeesan, Chairman, K J Research Foundation,
152 Poonamallee High Road, Chennai - 600084, Tamil Nadu, India
Ph: 044 26411513
Email : kjresearchfoundation@gmail.com, kjh@rediffmail.com

Materials and Methods

The lymphatic flow assessment system is a portable instrument used to visualize lymphatic morphology and function with the help of seven miniature radiation detectors. These are used to track the lymphatic flow by means of a radioactive tracer like Tc 99m HSA injected into the lymphatic system. These detectors are placed at the ankle, knee, and inguinal point on each limb/side of the body and one at a location corresponding to the liver (Figure 1). These points are used for studying lymphatic of the lower limb. The counts are taken for eight minutes in each session after the tracer is injected into the body. The counts taken are stored in a database for future use. An interactive user interface facilitates easy operation and interaction with the database. From the time history of activity at various locations in the body, the health of the lymphatic flow is inferred. The counts at all locations are displayed in various types of graphs like histogram, scattered plot and line curves with both the online and offline values of the counts. The numeric value of counts in each detector is shown online for every minute.

The schematic block diagram of the hardware of the instrument is as shown below. The system is configured in four sections with Detectors and Signal conditioners forming front end and counting system along with PC for user interface, data archival and presentation. The instrument has seven independent amplifiers with individual discriminators. The gain is adjustable in the range of 100 to 300 and discriminator settings are preset to look at the energy range of Tc -99m.

The software requirements mainly can be divided under the following sub modules:

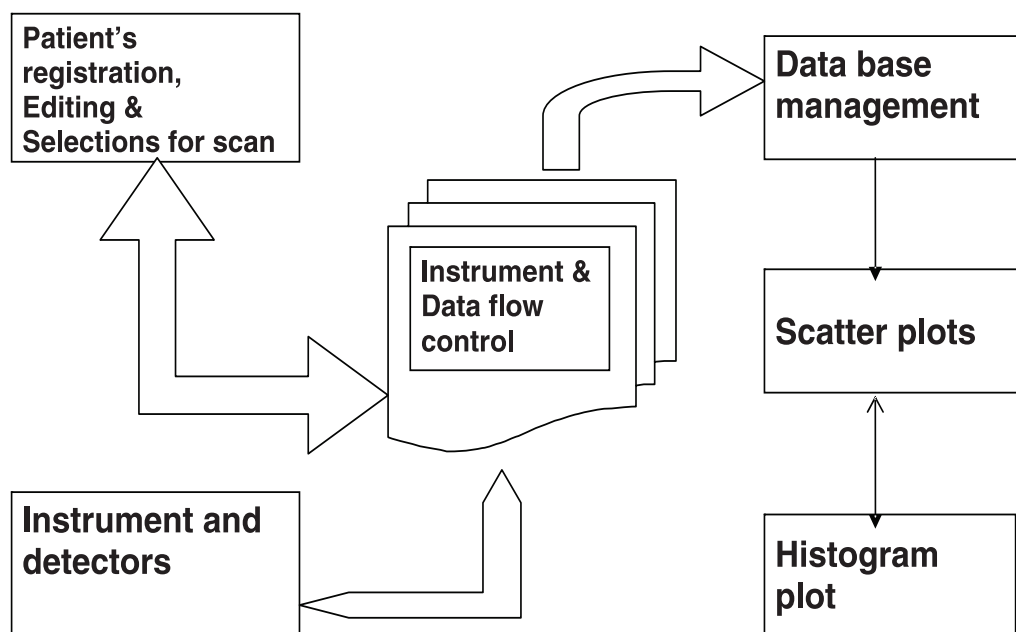


Figure 1: Photograph showing the detectors are connected and counting is being taken

Functional modules and Screens

- Main menu for interface
- Patient code, details for new registration
- Edit or search / select patient for instrument control
- Instrument control and save counts data
- Display data as scatter plots / histograms/ on line numeric format
- To create & update database tables

System Design

The software is developed in visual Basic 6.0 as front end and Microsoft Access as backend database. Various modules and their functions are listed below along with features.

- o User-friendly menu for interface.
- o Automatic patient code allocation.
- o To get the patient details and provide facilities for new registration.

- o To search and edit In-patients details.
- o To search and select patient for instrument control or data view.
- o To give start of counting command, to instrument on user's request.
- o Display online data as Scatter plots, histograms or as numeric value.
- o Display offline data as histograms and flow curves
- o To archive the complete data regarding patient and their scan records.

Data processing & Presentation

Counts data in terms of Counts/sec (cps) is monitored every second and the average 60 readings in a minute is saved in *counts* table as average cps. Thus over a period of eight minutes, in each session, the *counts* table will have eight readings which are the average cps in that minute. This data is used for displaying scatter plots (both Online & Offline). The average session is taken as the average of these eight readings and is saved in *Average* table. This data is used for displaying histograms (both Online & Offline)

In addition, during each session the real time counts for each minute in terms of average cps is displayed in the numeric display. Numeric display is only for viewing real time data gathered in that session. Offline data can also be viewed as flow curves where the X-axis is divided into 3 or 4 segments for left & right side of the body. Each session data is plotted in separate colors.

The patient details are common to all these graphs to keep track of patient - data links.

- o The counts axis can be selected as linear or logarithmic.
- o The various graphs can be seen on the screen in 3 modes - Left, Right & Both.

Scanning Procedure

The following are the locations at which micro detectors have to be kept.

Lower limbs:

- Point-1:** Upper limit of the medial malleolus of tibia.
- Point-2:** A point in the middle of the joint line of knee on the medial aspect and in the same vertical line as Point-1 (Noted as knee).
- Point-3:** A point in the middle of the line joining the anterior superior iliac spine and the pubic tubercle (noted as Inguinal point).

Liver Reference Point

Points on the lowest palpable right inter costal space in the mid auxiliary line.

Materials

Insulin syringe with 28 swg needle.

Lyophilized Human Serum Albumin (Figure 2) of Stanus tartarate reconstituted in 10mCi/ml with Tc 99m.

Dose: 0.5 mCi in 0.05 ml for each limb.

Route of administration: Intradermal injection on second web space in the lower limbs.



Figure 2: Lyophilized Human Serum Albumin

Procedure

The positions of the detectors are marked by marking ink on the patient body. With the patient in the supine lying position keep the detectors in the stipulated anatomical points (ie.3 on each side - right & left & one on the liver area). Injection of Tc 99m HSA in the above said dose is given in both lower limbs one after the other. Counts are taken during the interval of 0-8 min (Session1). The detectors are removed and massage is given on both sides for 5 minutes. The detectors are re fixed and counts are taken in the interval of 15-23 min (Session2). Again the detectors are removed and the patient is made to walk for 45 minutes on level ground. Again detectors are Refix and counts are taken in the interval of 60-68 minutes (Session3). Again the detectors are removed and the patient is made to walk. Then the detector is fixed and counts are taken in the interval of 180-188 minutes (Session4).

Software Description

The main screen displayed first when the flow assessment system executable file is executed. The title bar contains the name, current date and time. The window consists of menu with list of items, which we can select and the appropriate window will be opening. In the menu bar there are four main menu items namely

o **PATIENT DETAILS**

Details about the patients, such as name, address, sex, age etc. User can view, edit, or delete the patient details from the patient.

o **DIAGNOSIS**

Select the patient for diagnosis and view the report in diagrammatic representation both online and offline. Also the corrected diagrams and the velocity are also seen in this.

o **HELP**

Help file consist of content about the lymphoscintigraphy and the causes and the usage of diagnosis methods and the instruments used in it.

o **EXIT**

Exit ends the operations done in application and exits the application.

The patient details menu item contains four sub categories such as

o **ADD PATIENT**

Adding new in-patient details in the database for the diagnosis of lymphoscintigraphy. Each patient is given a unique patient id and it is automatically generated.

o **DELETE PATIENT**

If the detail of a patient is no more needed then it can be removed from the database by giving the patient id created for each patient.

o **EDIT PATIENT**

Editing of patient details includes a particular detail is been modified, like change of address user can change the address for the patient with the patient id.

o **VIEW PATIENT**

Just for viewing the patient information that is been given in the registration time.

Each of the above items link to individual forms

By clicking add patient from patient details menu item, the form will be opened. For adding new patient, the details are filled which are asked in two frames as patient details and hospital details, by pressing submit button the new patient is added to the database. Two fields in this form are predefined. They are patient id and registered date. Every patient is identified uniquely by the patient id, which is generated automatically. The registered date is automatically the current date. Delete patient form selected from the patient details menu item. In this form patient information can be deleted from the database permanently data's related to that patients are also deleted.

To view or to edit the patient is first selected by searching or by selecting from list of patients. This is the view patient form just to view the patient information and can't edit the information. By clicking the edit patient from patient details menu item information of any patient can be edited.

In search patient form, there are four categories such as

- o Name (name of the patient)
- o Patient id (unique identification code for every patient)
- o Age (age of the patient)
- o Sex (gender whether male or female)

The keywords matching the database information are listed in the flex grid sheet in a form. The search result also displayed in this form only, and also the entire list can be also shown here.

This flex grid displays five columns as

- o Code (unique id for every patient).
- o Name (name of the patient).
- o Follow up (how much time the diagnosis is done).
- o Date of monitoring (date when the diagnosis is done).

Offline help is included in the software. There are only specific help topic are included here in this help. This will appear by pressing the menu item help from the welcome screen. This help is created in html (hypertext markup language) and then it is included in this form. Passing from one page to another is done by hyperlink text, which glow in blue color. By pressing close button help window can be closed. Exit item in the main menu closes the window and exits the application.

In the main menu, menu item named diagnosis consist of one menu item and a sub menu, the sub menu diagrams contains four menu items.

o **CONTROL**

Leads to the diagnosis page for collecting the counts and represent in the online graph view, like histogram, scattered plot, and flow curve.

o **DIAGRAMS**

o **VELOCITY**

Velocity of the radiotracer material traveling from one point to another where the detectors are placed.

o **FLOW VIEW**

Flow of radiotracer in each detector point is represented in percentage as the first detector point is taken as the actual percentage. The

distance between the detectors is also shown here.

o **CORRECTED VIEW**

The correction in received counts is made and displayed in form of graphs. Two main corrections are decay correction and the background correction.

o **OFFLINE VIEW**

The graph shown in the control form is online graph, which is seen through the online counts. Then the counts are stored in database; displaying graph by getting the values from the database is offline graph.

To go to control form, control is selected from the menu item diagnosis. After selecting the patient the input form will be displayed. In this form the input values are all given for control. First distance between each detectors are measured and entered in appropriate positions and to find velocity the multiplicity value of background is given, after that calculate background button is pressed for calculating background radiation. It will be calculated for eight minutes that is 480 seconds. Remaining seconds will be displayed in the form. After calculating the background the submit button is pressed. After pressing submit button in the input form the values will be stored in database and the selection of COM port will be displayed, in which the converter is connected to. After selecting the COM port the start button will appear. Until the injection is injected in the lower limb on both sides one after another the button should not be pressed. After injection the button must be pressed. After selecting the start button the counting is on, that is indicated by a blinking text "COUNTING ON". The elapsed time is also shown there in a frame with the patient name and id. The graph can be visualized online in this form, but after one minute only the scattered graph may be visible and after first session only the histogram is visible. The numerical counts and the scattered graph will be automatically updated for every one-minute, because for every one minute the average count is taken and stored in the counts table in database. After eight minutes the average counts will be stored in the average table in the database and histogram is updated. This process will continue for four sessions each of eight minutes. At any time the online numeric counts can be seen by pressing numeric button on the control form. In the numeric counts form it shows separate data's for each and every detector positions, and also the last received counts time is displayed on the top of the screen.

Conclusion

The software developed facilitates simultaneous lymphatic flow measurement at different locations in the

limb after the injection of radioactive tracer (Tc99m, 140 KeV). The database stores all the information about the patients, referring Doctors. Also the flow counts at all points is indicated each time and stored for each cycle and Reports are generated for the patients. This makes the diagnosis easier and quick analysis. These are used to track the lymphatic flow by means of a radioactive tracer like Tc 99m HSA injected into the lymphatic system. Treatment of lymphedema should be undertaken only after a thorough diagnostic evaluation has been done according to accepted guidelines by qualified practitioners. Based on the above said procedure, the counts and the velocity for 50 subjects has been done. The results for the subjects has been evaluated by the developed software. The results shows that when the counts measured are less and at the same time the velocity measured at the various places are also less. This shows the poor lymphatic flow. The results clearly indicates that the when the counts are more and the velocity is more, then the lymphatic flow is normal. In other words if the count and the velocity are less, then the lymphatic flow is very poor.

ACKNOWLEDGEMENT

We wish to thank Dr. Somayaji and his team at Indiragandhi Center for Atomic Research (IGCAR) Kalpakkam for fabricating the circuit.

Conflict of interest:	All authors declare no COI
Ethics:	There is no ethical violation as it is based on voluntary anonymous interviews
Funding:	This project is funded by the Board of Research in Nuclear Science (BRNS)
Guarantor:	Dr.K.Jagadeesan will act as guarantor of this article on behalf of all co-authors.

References

1. NLN Medical Advisory Committee "The Diagnosis and Treatment Of Lymphedema", NLN Position Paper, 2011.

