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PROJECT COMPLETION REPORT

1. **Project Number** : 6215

2. **Title of the Project** : Development of a prototype Safety System to detect early and to prevent contrast extravasation, especially in large volume intravenous power injections of contrast agents in CT and MR angiography

3. **Funding Agency Name** : SCTIMST, TDF

4. **Project Reference Number provided by the Funding Agency**: 6215

5. **Principal Investigator (Name & Address): Dr Bejoy Thomas**

   Professor, Dept of Imaging Science and Interventional Radiology
   SCTIMST

6. **Co-Investigators (Name & Address):**
   i. Mr. Sarath S Nair, Dept of Medical Devices Engineering, BMT Wing, SCTIMST
   Mr Manoj S, Dept of Clinical Engineering, SCTIMT
   Dr Unnikrshnan K P, Dept of Anaesthesiology, SCTIMST

7. **Implementing Institution** : SCTIMST

8. **Collaborating Institutions** : Nil

9. **Date of Commencement** : 18/01/2016

10. **Duration** : 2 Years

11. **Date of Completion** : 31/3/2018

12. **Objectives as approved :**
    This project aims to develop a safety check system in detecting contrast extravasation very early and preventing further injection on detecting the same using surface optical detectors and activating relay switches.

Objectives:

Development of infrared optical sensor-based relays in detecting early extravasation in power injections of contrast medication, thereby helping to automatically cut off further injection and prevent further large volume extravasation.

13. Deviation made from original objectives if any, while implementing the project and reasons thereof :

Nil

14. Field/Experimental work giving full details of summary of methods adopted, data collected supported by necessary tables, charts, diagrams and photographs :

Introduction

Considering the potential adverse events that can happen due to extravasation, technological interventions are highly essential. However, the existing methods proposed in prior arts are limited using sensors that can be placed on to the skin surface surrounding the region of IV puncture. The sensors may obtain the information of extravasation either through variations in ultrasonic frequencies or by infrared absorption differences due to the extravasated liquid. The use of these devices is limited due to lack of precision and speed in identifying spatial localization of extravasation. Hence, in this project a system consisting of an infrared sensors and optical image processing gated infusion control is proposed. The image processing method is optimized to the IV puncture site including the region of the veins, which are continuously monitored and analysed before and during the power injection. Any change in the image due to early extravasation is detected with computerized picture matching and the system will immediately shut down the infusion pump, by turning of its electrical power thereby eliminating further damage due to large volume leakage of contrast and saline. The system description, principle of operation and device description are detailed below.

System Description

The device presented here is a system for detecting extravasation which may occur during power injections of intravenous contrast agents for image enhancements during CT angiograms. The device consists of an image acquisition device, an image analysis unit, a relay unit and a display unit. The image acquisition unit contains infrared light emitting diodes and a miniature camera and a microcomputer to perform the image analysis. The relay unit contains a relay, a trigger mechanism and a power plug. The relay is electrically connected to 230V power supply unit.

The power cord of external infusion pump which is programmed to deliver the bolus quantity of the contrast agent is connected to the relay unit of the system. Thus, the relay unit provides the electrical power to operate the power injector.

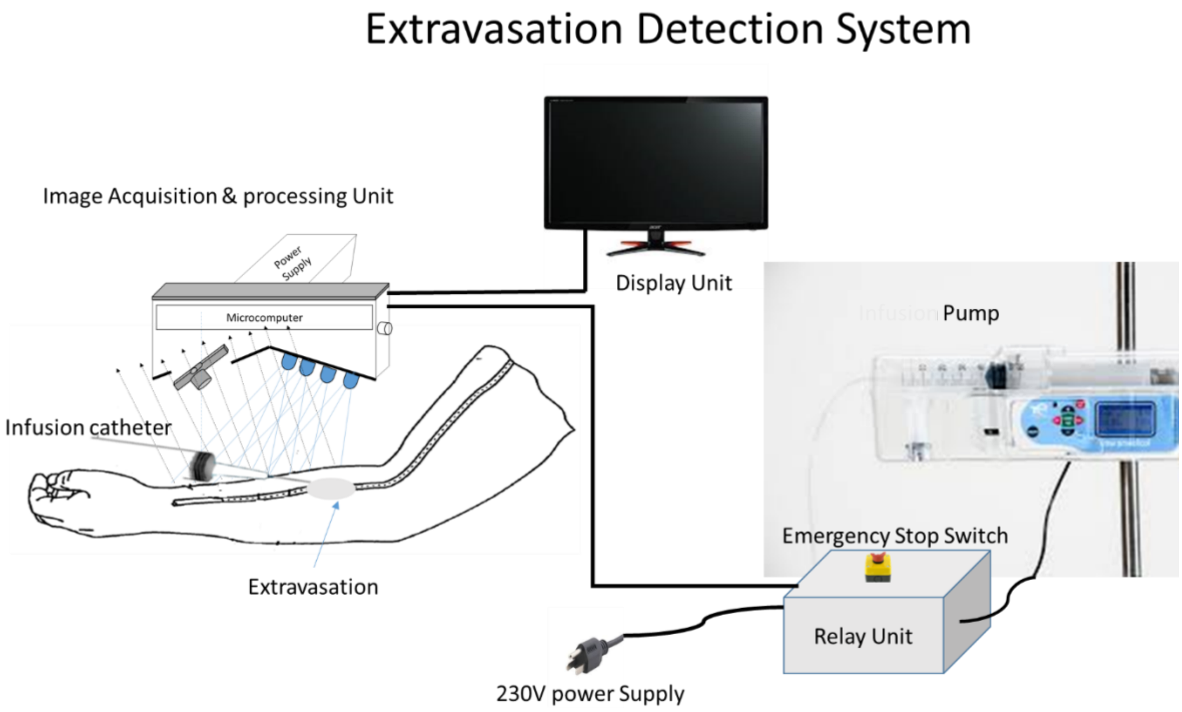

Fig 1. Architecture of Extravasation detection system

Principle of Operation

The extravasation detection system works on the principle of Image processing, based on selective absorption difference of near infrared wavelength by blood and tissues. As shown in Fig 1, the IR LED cluster is a distributed light source which illuminates the entire surface of the part of the human body where veins need to be located. The device is designed such a way that the IR LED cluster and the camera are placed in two inclined planes coinciding each other at an angle, such that the infrared radiations emitted by the distributed IR LEDs fall towards the camera after reflecting from the entire skin surface. IR LEDs are uniformly distributed over one of the geometrical plane in the back side of the device. The IR camera present in the device is mounted on a tilting disc over the second geometrical plane. By tilting the disc about its center, the infrared radiations reflected from different part of the skin are made to fall on the camera.

When the device is powered on, the infrared light emitting diodes (IR LEDs) uniformly illuminates the surface of the body where veins are to be located. The IR LEDs emit infrared radiations of infrared region which penetrate the skin to a few millimeters in depth where peripheral veins are present and get reflected. The IR LEDs emitting radiation of wavelength with highest absorption by hemoglobin is selected for the purpose. The hemoglobin present in the blood passing through the veins absorbs the infrared radiations and the tissues surrounding the veins reflect the radiation. The reflected infrared radiation falls on the IR camera to produce an infrared image of the area under view. Since the hemoglobin present in the vein absorbs infrared radiations more than surroundings, veins appear to be dark in color. The electronic hardware unit connected to the camera adjusts the brightness setting to minimum and contrast settings to maximum to enable feeble infrared radiation detection reflected from skin surface. The electronic hardware triggers the camera to obtain images continuously. The obtained images are passed through an image processing algorithm for enhancing the quality by filtering, detecting the edges. The processed images are displayed in a screen. A small knob attached to the sides of the device is used to tilt the disc to which camera is attached. By adjusting the knob, the area of view of the part of the body can be changed and a larger area of the human body can be scanned to trace the veins easily. The tilting disc may be attached to an electric motor and controlled by a microcontroller or through mechanical gears for smooth variation in its angle. Thus, the part of body viewed on the screen can be varied without moving the device; thereby tracing the veins completely and reducing the time for venous puncture. So the image detection and processing unit can be used for safe venous puncture initially itself.

The IR LED of 850/940nm is used to liberate infrared radiations which illuminate the IV injection site. The infrared radiations penetrate the skin to a depth of few mm where the peripheral veins are present. The de-oxygenated blood in the veins absorb the radiations and the surrounding tissues reflect it. The camera present in the acquisition unit reads the reflected light and converts it into an image. Due to the absorption difference between the veins and the surrounding tissue, the veins appear dark in color than the surrounding tissues. The microcomputer triggers the image acquisition unit to grab the pictures at frequent intervals and transfer to the image analysis unit. The image analysis unit obtains the image at an interval and subtracts the latter image with a former image to a ‘difference image’. When contrast column replaces the blood in the vein, during an injection, the ‘dark’ vein is replaced by a ‘brighter’ vein ‘ghost’, which still obeys the boundary characteristics, previously defined by image processing and edge enhancement. The unit, then checks for any difference pixel of high brightness, outside the contour of the vein, as an indicator for extravasation. If the image has small variations, then the ‘difference image’ shall have noisy bright spots. A filter removes this noise and create s smooth image. The unit processes the image to identify the number of pixels having high brightness is crossing the threshold limit for extravasation. If the difference image white pixels cross the threshold value, an alarm is actuated, and written information is provided to the display unit. The microcomputer then initiates one of its digital output to high state. The digital input is electrically wired to the coils of a relay which is normally configured in Normally Close condition. The relay unit contains a relay, a trigger mechanism and a power plug. The relay is electrically connected to 230V power supply unit.

The power cord of external pressure infusion pump which is programmed to deliver the bolus quantity of the contrast agent is connected to the relay unit of the system. Thus, the relay unit provides the electrical power to operate the infusion pump. When powered on the relay unit is in “Normally Close” mode, it provides 230V AC power to the infusion pump to operate. When the relay is triggered with a 5V low power signal, the relay shifts its position to “Open” condition which cuts off the power to the infusion pump. In this way the infusion pump can be controlled to prevent continued injection and damage due to the extravasation. The microcontroller-based image processing unit triggers the relay with the necessary 5V for its operation after detection of early minimal extravasation, which is clinically insignificant and which cannot be detected with naked eye, and hence prevent larger clinically significant continued extravasation, in sub second timeframe.

5.2Parts of Extravasation detection system

A shown in Fig 2, the main parts of the Extravasation detection system are

1. Raspberry Pi 3 Type B or equivalent
2. Raspberry Pi NoIR TTL camera or equivalent
3. HDMI LCD Display
4. Power Supply
5. IR LEDs
6. Holder
7. Relay Unit
8. Emergency Switch

Subsystems Block Diagram

The detailed block diagram of various subsystems and its interconnections are given in the fig 2.

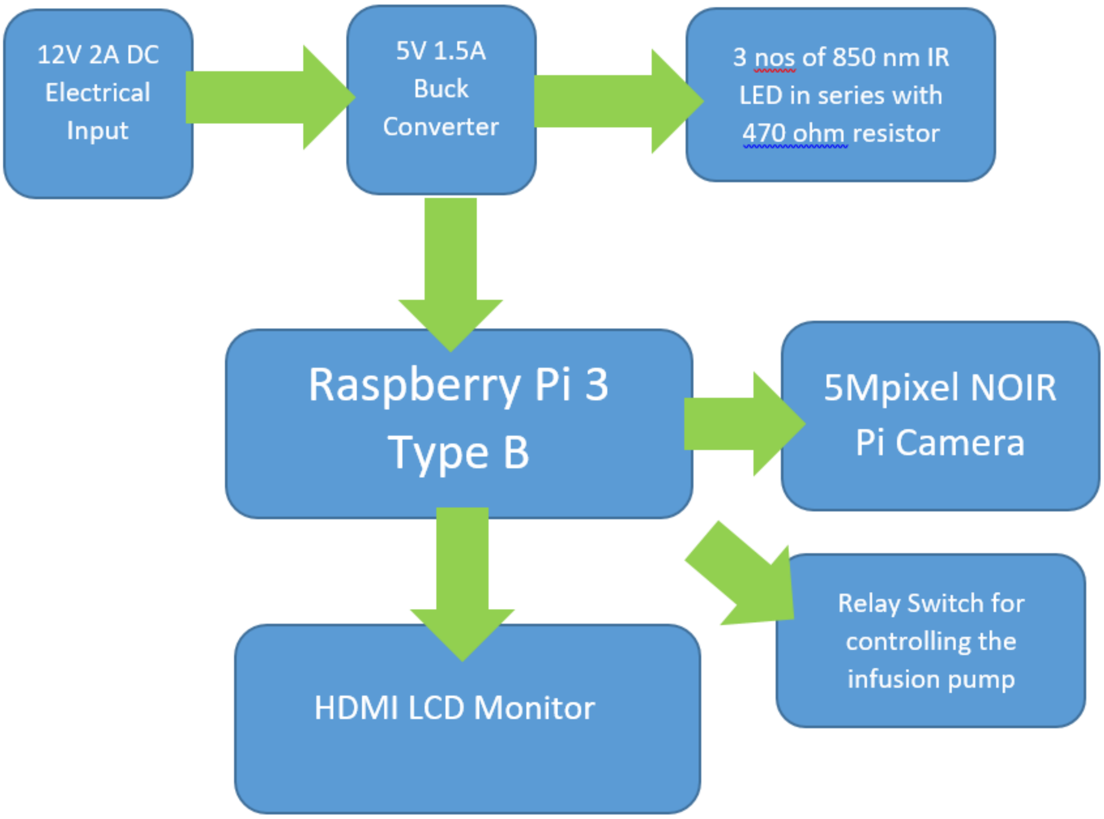

Fig 2. Subsystems block diagram of Extravasation detection system

15. Detailed analysis of results :

A prototype is developed to check the feasibility of the method proposed in this method. To test the working and effectiveness of the developed system, a model of dummy hand is prepared by rolling a sponge on a PVC tube of 20 cm, and wrapped with a plastic sheet along with a silicon tube of diameter 5mm inside it. A three-way connector is connected to an end of the tube and a 50 ml syringe filled with a colored solution is connected. The Image Acquisition & Analysis Unit is mounted on stand which is connected to HDMI monitor and an emergency ON/OFF button. The model of the dummy hand is placed beneath the IR sensor system and is focused to view the tube properly. The syringe is used for injecting the colored solution (mimicking venous blood) to flow through the tube till the loop gets completed. A sight is marked on the dummy hand model and is punctured on the area with needle. The colored solution is again injected in to the tube. The solution gets leaked through the punctured hole and gets spread in to the sponge which is detected by the vein detection system as extravasation. A alarm goes high and the message “EXTRAVASATION DETECTED” is displayed on the monitor. The emergency switch then needs to be pressed. Which cuts off a relay switching of the injecting device.

16. Summary sheet of not more than 2 pages under the following heads : (Title, Introduction, Rationale, Objectives, Methodology, Results, Translational Potential)

Title: Development of a prototype Safety System to detect early and to prevent contrast extravasation, especially in large volume intravenous power injections of contrast agents in CT and MR angiography

Objectives:

Development of infrared optical sensor-based relays in detecting early extravasation in power injections of contrast medication, thereby helping to automatically cut off further injection and prevent further large volume extravasation.

Introduction

World over millions of CT angiography studies are being performed every year. Contrast enhanced CT and MR angiography requires power injection of contrast media followed by saline chase at a very fast rate. Automated power injections may result in extravasation of large volumes and may or can lead to severe tissue damage. Although IV lines are secured with utmost care in angiographic examinations, chance of extravasation of large volumes of contrast into the extra vascular – extracellular space (interstitium) is always a potential risk during these injections, especially in children and in older uncooperative patients. Even though the percentage risk is less, due to high volumes of the performed CT angio studies, this complication can run into high numbers and development of safer injection monitoring systems are required to prevent such potentially dangerous adverse events. Extravasation not only hampers the angiography quality - many times leading to repeat studies- but also poses a serious risk to patient safety. Till now, the power injections are manually monitored and injections are stopped in the event of visual appreciation of local extravasation or when the patient reports discomfort during the injection. Hence a better method which can detect extravasation immediately after its onset and turn off the power injection module or the infusion machine will be highly beneficial to patients. Such systems will improve the safety of the CT angiograms and avoid unnecessary sufferings to patients. More over development of such fast and efficient detection systems can be further utilized for improving injection safety in other potentially dangerous IV injections like chemotherapy.

Prior Art Survey

Since multiple systems with interdependency are involved in CT angiogram imaging, not much research has been conducted so far in this area for injection safety of large volume contrast. However, some earlier research conducted has come up with certain methods for early detection of the extravasation. The US patent US2002/0172323A1 is one such disclosure which describes a method consisting of X-Ray imaging system with pixilated detector have been disclosed for detecting extravasations. In US 20040215081A1, A method for the real-time visualization and detection of extravasated and or infiltrated fluid and substances, including blood, that occur near the cannulation site of an injection is described wherein illumination or transillumination with near infrared light is used to image the contrast in real-time between absorbing and no absorbing sub dermal and intra dermal structures of blood vessels and remaining surrounding tissue, foreign substances and other structures in order to establish a baseline image of the body area of interest, and any new image is monitored and compared with the baseline image to detect the extravasations.

In US5964703A/1994, a medical extravasations device is disclosed, which has an electrode patch that can attach to the skin for sensing electrical information. The device monitors the impedance of the tissue during injection procedures by and checks for extravasations by comparing with baseline value. In another patent W01999015074A1, a device is disclosed which detects extravasations optically. The device includes an electrical control module and a disposable conduit which contains optical source and a sensor. The detector detects the light from the light source that is reflected, scattered, diffused or otherwise emitted from the patient. The electronics control module processes signals from the detector and evaluates whether extravasations has occurred.

However, the above said technologies are not matured enough to be applied in real clinical situations and are not available at low cost. Since these injections are happening at a very fast rate (eg: 5ml/sec), it is often impossible to manually stop injections before considerable volumes have already been injected, there by practically having no effective check mechanism to stop extravasations in such circumstances using the existing technologies. Moreover, with the newer non - ionic contrast media, patient experiences less pain during inadvertent injections into the interstitium, but later can produce complications due to tissue toxicity of the contrast media and or by the development of compartmental compressions syndromes.

Design Objectives

All the prior arts show invasive methods for detection of extravasation and no provision is provided for stopping it. Moreover, invasive placements of the sensors cause discomfort to the patients and need clinician training for injections.

Thus, it was the objective of this project to develop a system which uses noninvasive techniques for early detection of extravasation and prevent further damages due to large volume extravasation of contrast agents and other fluids. For this, the project aimed to use infrared sensors and image processing techniques to detect the onset of extravasation and control the power given to a injector machine or infusion machine for stopping injection, in case of such detection.

The system has all essential subsystems which would remotely observe the location of the power injection and trigger an electromechanical switch connected to the power injector machine, in case extravasation is detected. Depending on the speed of analysis of the image processing system and the electromagnetic actuator, the power injector can be turned off to avoid further damages as soon as an early extravasation is detected.

Another objective of the design is to develop a system as simple as possible, which can be placed along with the power injector near to the CT machine and operate in tandem with the power injector.

Design Methodology

1. Introduction

Considering the potential adverse events that can happen due to extravasation, technological interventions are highly essential. However, the existing methods proposed in prior arts are limited using sensors which can be placed on to the skin surface surrounding the region of IV puncture. The sensors may obtain the information of extravasation either through variation in ultrasonic frequencies or by infrared absorption differences due to the extravasated liquid. The use of these devices is limited due to lack of precision and speed in identifying spatial localization of extravasation. Hence, in this project a system consisting of an infrared sensors and optical image processing gated infusion control is proposed. The image processing method is optimized to the IV puncture site including the region of the veins, which are continuously motitored and analyzed before and during the power injection. Any change in the image due to early extravasation is detected with computerized picture matching and the system will immediately shut down the infusion pump, by turning of its electrical power thereby eliminating further damage due to large volume leakage of contrast and saline. The system description, principle of operation and device description are detailed below.

2. System Description

The device presented here is a system for detecting extravasation which may occur during power injections of intravenous contrast agents for image enhancements during CT angiograms. The device consists of an image acquisition device, an image analysis unit, a relay unit and a display unit. The image acquisition unit contains infrared light emitting diodes and a miniature camera and a microcomputer to perform the image analysis. The relay unit contains a relay, a trigger mechanism and a power plug. The relay is electrically connected to 230V power supply unit.

The power cord of external infusion pump which is programmed to deliver the bolus quantity of the contrast agent is connected to the relay unit of the system. Thus, the relay unit provides the electrical power to operate the power injector.

3. Principle of Operation

The extravasation detection system works on the principle of Image processing, based on selective absorption difference of near infrared wavelength by blood and tissues. As shown in Fig 1, the IR LED cluster is a distributed light source which illuminates the entire surface of the part of the human body where veins need to be located. The device is designed such a way that the IR LED cluster and the camera are placed in two inclined planes coinciding each other at an angle, such that the infrared radiations emitted by the distributed IR LEDs fall towards the camera after reflecting from the entire skin surface. IR LEDs are uniformly distributed over one of the geometrical plane in the back side of the device. The IR camera present in the device is mounted on a tilting disc over the second geometrical plane. By tilting the disc about its center, the infrared radiations reflected from different part of the skin are made to fall on the camera.

When the device is powered on, the infrared light emitting diodes (IR LEDs) uniformly illuminates the surface of the body where veins are to be located. The IR LEDs emit infrared radiations of infrared region which penetrate the skin to a few millimeters in depth where peripheral veins are present and get reflected. The IR LEDs emitting radiation of wavelength with highest absorption by hemoglobin is selected for the purpose. The hemoglobin present in the blood passing through the veins absorbs the infrared radiations and the tissues surrounding the veins reflect the radiation. The reflected infrared radiation falls on the IR camera to produce an infrared image of the area under view. Since the hemoglobin present in the vein absorbs infrared radiations more than surroundings, veins appear to be dark in color. The electronic hardware unit connected to the camera adjusts the brightness setting to minimum and contrast settings to maximum to enable feeble infrared radiation detection reflected from skin surface. The electronic hardware triggers the camera to obtain images continuously. The obtained images are passed through an image processing algorithm for enhancing the quality by filtering, detecting the edges. The processed images are displayed in a screen. A small knob attached to the sides of the device is used to tilt the disc to which camera is attached. By adjusting the knob, the area of view of the part of the body can be changed and a larger area of the human body can be scanned to trace the veins easily. The tilting disc may be attached to an electric motor and controlled by a microcontroller or through mechanical gears for smooth variation in its angle. Thus, the part of body viewed on the screen can be varied without moving the device; thereby tracing the veins completely and reducing the time for venous puncture. So the image detection and processing unit can be used for safe venous puncture initially itself.

The IR LED of 850/940nm is used to liberate infrared radiations which illuminate the IV injection site. The infrared radiations penetrate the skin to a depth of few mm where the peripheral veins are present. The de-oxygenated blood in the veins absorb the radiations and the surrounding tissues reflect it. The camera present in the acquisition unit reads the reflected light and converts it into an image. Due to the absorption difference between the veins and the surrounding tissue, the veins appear dark in color than the surrounding tissues. The microcomputer triggers the image acquisition unit to grab the pictures at frequent intervals and transfer to the image analysis unit. The image analysis unit obtains the image at an interval and subtracts the latter image with a former image to a ‘difference image’. When contrast column replaces the blood in the vein, during an injection, the ‘dark’ vein is replaced by a ‘brighter’ vein ‘ghost’, which still obeys the boundary characteristics, previously defined by image processing and edge enhancement. The unit, then checks for any difference pixel of high brightness, outside the contour of the vein, as an indicator for extravasation. If the image has small variations, then the ‘difference image’ shall have noisy bright spots. A filter removes this noise and create s smooth image. The unit processes the image to identify the number of pixels having high brightness is crossing the threshold limit for extravasation. If the difference image white pixels cross the threshold value, an alarm is actuated, and written information is provided to the display unit. The microcomputer then initiates one of its digital output to high state. The digital input is electrically wired to the coils of a relay which is normally configured in Normally Close condition. The relay unit contains a relay, a trigger mechanism and a power plug. The relay is electrically connected to 230V power supply unit.

The power cord of external pressure infusion pump which is programmed to deliver the bolus quantity of the contrast agent is connected to the relay unit of the system. Thus, the relay unit provides the electrical power to operate the infusion pump. When powered on the relay unit is in “Normally Close” mode, it provides 230V AC power to the infusion pump to operate. When the relay is triggered with a 5V low power signal, the relay shifts its position to “Open” condition which cuts off the power to the infusion pump. In this way the infusion pump can be controlled to prevent continued injection and damage due to the extravasation. The microcontroller-based image processing unit triggers the relay with the necessary 5V for its operation after detection of early minimal extravasation, which is clinically insignificant and which cannot be detected with naked eye, and hence prevent larger clinically significant continued extravasation, in sub second timeframe.

4. Parts of Extravasation detection system

A shown in Fig 2, the main parts of the Extravasation detection system are

1. Raspberry Pi 3 Type B or equivalent
2. Raspberry Pi NoIR TTL camera or equivalent
3. HDMI LCD Display
4. Power Supply
5. IR LEDs
6. Holder
7. Relay Unit
8. Emergency Switch

A prototype is developed to check the feasibility of the method proposed in this method. The picture of the prototype of the device is shown in Fig 3. The results of application of Extravasation detection system for different situations are shown in Fig 4-7.

To test the working and effectiveness of the developed system, a model of dummy hand is prepared by rolling a sponge on a PVC tube of 20 cm, and wrapped with a plastic sheet along with a silicon tube of diameter 5mm inside it. A three-way connector is connected to an end of the tube and a 50 ml syringe filled with a colored solution is connected. The Image Acquisition & Analysis Unit is mounted on stand which is connected to HDMI monitor and an emergency ON/OFF button. The model of the dummy hand is placed beneath the IR sensor system and is focused to view the tube properly. The syringe is used for injecting the colored solution (mimicking venous blood) to flow through the tube till the loop gets completed. A sight is marked on the dummy hand model and is punctured on the area with needle. The colored solution is again injected in to the tube. The solution gets leaked through the punctured hole and gets spread in to the sponge which is detected by the vein detection system as extravasation. A alarm goes high and the message “EXTRAVASATION DETECTED” is displayed on the monitor. The emergency switch then needs to be pressed. Which cuts off a relay switching of the injecting device. Fig7

17. Contributions made towards increasing the state of knowledge in the subject :

In this project a novel method for the detection of extravasation of contrast agent happening due to the oozing out of contrast agents during the application of power injections is proposed.

18. Conclusions summarising the achievements and indication of scope for future work :

In this project a novel method for the detection of extravasation of contrast agent happening due to the oozing out of contrast agents during the application of power injections is proposed. The method consists of a noninvasive technique applying the principles of infrared based vein detection and image processing bases analysis on a microcomputer to detect extravasation at the time of its onset. A device is developed, which consists of an image acquisition and analysis unit, a relay unit and a display unit.

The image acquisition unit gets images from the site of injections at regular intervals and is given to the analysis unit. A microcomputer loaded with an extravasation detection algorithm, process the images and triggers an output switch in the relay unit. In the developed system, it is proposed to connect electrical power to the power injector through the relay unit. The relay unit normally provides power to the injector for its operation but cuts down when an early extravasation is detected. Thus, in this way, serious complications due to masssive extravasations in power injections of CT contrast can be avoided. Regular usage of the system along with CT angiography provides confidence to the clinicians, care takers and eliminates the sufferings of the patients to a great extent.

As part of the project, one prototype is developed, and the concept is tested in bench top condition using dummy hand model made of sponge and manual injections. For establishing the safety and efficacy of its operation, it is proposed to have a clinical testing of the system in actual practice as a future work.

19. Science and Technology benefits accrued :

a. List of research publications with complete details :

b. Manpower trained on the project :

		i.	**Research Scientists or Research Fellows**	**:**	**0**
		ii.	**No. of PhD's produced**	**:**	**0**
		iii.	**Other Technical Personnel trained**	**:**	**1**
	c.	**Patents taken, if any**		**:**	A Portable device and a method for locating the superficial veins of the human body for venous puncture and tracing the route of veins with peripheral scanning (Chitra Vein Viewer)
	d.	**Products developed, if any**		**:**	Extravasation Detection System. Spin off technology is commercialised as Chitra Vein Viewer

20. Abstract: (In 300 words for possible publication in ...... Bulletin)

a. Background:

World over millions of CT angiography studies are being performed every year. Contrast enhanced CT and MR angiography requires power injection of contrast media followed by saline chase at a very fast rate. Automated power injections may result in extravasation of large volumes and may or can lead to severe tissue damage. Although IV lines are secured with utmost care in angiographic examinations, chance of extravasation of large volumes of contrast into the extra vascular – extracellular space (interstitium) is always a potential risk during these injections, especially in children and in older uncooperative patients. Even though the percentage risk is less, due to high volumes of the performed CT angio studies, this complication can run into high numbers and development of safer injection monitoring systems are required to prevent such potentially dangerous adverse events. Extravasation not only hampers the angiography quality - many times leading to repeat studies- but also poses a serious risk to patient safety. Till now, the power injections are manually monitored and injections are stopped in the event of visual appreciation of local extravasation or when the patient reports discomfort during the injection. Hence a better method which can detect extravasation immediately after its onset and turn off the power injection module

or the infusion machine will be highly beneficial to patients. Such systems will improve the safety of the CT angiograms and avoid unnecessary sufferings to patients. More over development of such fast and efficient detection systems can be further utilized for improving injection safety in other potentially dangerous IV injections like chemotherapy.

b. Materials:

1. Raspberry Pi 3 Type B or equivalent
2. Raspberry Pi NoIR TTL camera or equivalent
3. HDMI LCD Display
4. Power Supply
5. IR LEDs
6. Holder
7. Relay Unit
8. Emergency Switch

c. Results:

A prototype is developed to check the feasibility of the method proposed in this method.

To test the working and effectiveness of the developed system, a model of dummy hand is prepared by rolling a sponge on a PVC tube of 20 cm, and wrapped with a plastic sheet along with a silicon tube of diameter 5mm inside it. A three-way connector is connected to an end of the tube and a 50 ml syringe filled with a colored solution is connected. The Image Acquisition & Analysis Unit is mounted on stand which is connected to HDMI monitor and an emergency ON/OFF button. The model of the dummy hand is placed beneath the IR sensor system and is focused to view the tube properly. The syringe is used for injecting the colored solution (mimicking venous blood) to flow through the tube till the loop gets completed. A sight is marked on the dummy hand model and is punctured on the area with needle. The colored solution is again injected in to the tube. The solution gets leaked through the punctured hole and gets spread in to the sponge which is detected by the vein detection system as extravasation. A alarm goes high and the message “EXTRAVASATION DETECTED” is displayed on the monitor. The emergency switch then needs to be pressed. Which cuts off a relay switching of the injecting device.

d. Conclusion:

In this project a novel method for the detection of extravasation of contrast agent happening due to the oozing out of contrast agents during the application of power injections is proposed. The method consists of a noninvasive technique applying the principles of infrared based vein detection and image processing bases analysis on a microcomputer to detect extravasation at the time of its onset. A device is developed, which consists of an image acquisition and analysis unit, a relay unit and a display unit. The image acquisition unit gets images from the site of injections at regular intervals and is given to the analysis unit. A microcomputer loaded with an extravasation detection algorithm, process the images and triggers an output switch in the relay unit. In the developed system, it is proposed to connect electrical power to the power injector through the relay unit. The relay unit normally provides power to the injector for its operation but cuts down when an early extravasation is detected. Thus, in this way, serious complications due to masssive extravasations in power injections of CT contrast can be avoided. Regular usage of the system along with CT angiography provides confidence to the clinicians, care takers and eliminates the sufferings of the patients to a great extent.

As part of the project, one prototype is developed, and the concept is tested in bench top condition using dummy hand model made of sponge and manual injections. For establishing the safety and efficacy of its operation, it is proposed to have a clinical testing of the system in actual practice as a future work.

21. Procurement/Usage of Equipment: NA, development of prototype

Dr. Bejoy Thomas

(Name and Signature of PI)

Routing: *Signed copy of "Project completion Report" by PI → root@sctimst.ac.in, rpc@sctimst.ac.in*