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THE REVIEW OF DEVELOPMENT AND DESIGN OF BLOOD CENTRIFUGE MACHINE

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ABSTRACT

A blood collection monitor is a medical device used to prevent blood clotting and ensure proper mixing of anticoagulant fluid in the blood bag during a blood transfusion. This study focuses on designing an automated blood collection system with an inbuilt mixer for blood transfusions. The proposed design is equipped with a safety system in the form of a barrier indicator that is linked to an alarm. The alarm is triggered to alert the blood donor if there is an obstacle or if the blood volume in the bag does not increase by at least 20ml in one minute, according to the World Blood Bank Association guidelines. The device is compatible with three different sizes of blood bags. The amount of blood fluid entering the bag is detected using a load cell sensor and then converted into milliliter volume. An Arduino microcontroller controls the motor that drives the shaker used to collect the blood. The measurement results show no deviation, UA, or average error for the entire size of the blood bag, indicating that the device is reliable. In the future, the blood infusion system can be further developed to include flow rate measurements to determine the speed of blood during transfusion.

Keywords – ***Blood Collection, Evactainer, Arduino, Rocking motion, Centrifuge,***

[1] INTRODUCTION

During the process of blood collection from donors, a blood collection monitor is used to shake the blood in the bag and mix it with anticoagulants to prevent coagulation. The amount of blood that needs to be collected varies from 350ml to 450ml and current electronic blood collection monitors used in hospitals and laboratories require external power sources, which limits their use in rural areas and large-scale donation camps. To overcome this limitation, a mechanical blood collection monitor has been proposed that does not require any external power source. This monitor is designed to quantify the amount of blood and measure blood flow without the need for electricity. ANSYS and ADAMS were used to analyze the linkage mechanism and associated gear train, which further allows for the study of kinetic energy and torque. This study offers insights into the design considerations and systematic study of the mechanical blood collection monitor, which could be a promising solution for blood collection in areas with limited access to electricity. Copyright 2021 Elsevier Ltd. All rights reserved.

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Blood is essential for human beings as it carries oxygen, nutrients, hormones, and waste products throughout the body. It is made up of red blood cells, white blood cells, platelets, and plasma. There are seven types of blood (A+, A-, B+, B-, O+, O-, AB+), with O+ being the universal donor and AB+ being the universal recipient. In 1666, Richard Lower reported the first successful transfusion between animals. The blood collection monitor device is commonly used in hospitals and blood donation camps to facilitate this process.

Blood Donation Camp **Blood Collection Process**

The blood collection machine or monitor was first invented in 1947 by Joseph Kleiner. He is a modeling and data Engineer. He has a track record of designing & and implementing high-performance models. The Evacutainer is a modern vacuum glass tube used for blood collection. It was invented by Lawrence Allan Simpson in 1977. Between 1991 and 199 3, a plastic version called the Evacutainer Plus was developed by the Becton Dickinson Research Centre. The vacuum pressure in the tube ensures the correct quantity of blood is collected from the needle. One end of the needle punctures the vein while the other enters the rubber stopper in the tube. The earlier blood collection systems were difficult and imprecise, with etched lines on the borosilicate glass tube to indicate the amount of blood required. EDTA or Citrate was added to prevent blood clotting, and rubber stoppers sealed the tubes for transportation to the laboratory. The Evacutainer Plus Plastic process has been replaced with a blood collection machine to improve accuracy and efficiency. The blood collection monitor, patented in 197, is a device used to measure the flow of blood during collection. Dr. Gabrienl N. Hortobagyi was the inventor of this process.

Evacutainer **Evacutainer Plus**

Blood collection is an important process that requires precision and safety. A blood collection monitor plays a crucial role in ensuring these aspects by measuring blood and regulating its flow during collection. This device helps to ensure accurate and safe blood donation by monitoring the blood's speed and volume and providing alerts if any issues arise. The blood collection monitor gives a rocking motion to the blood bag to ensure the blood is properly collected. In the past, blood collection relied on manual methods such as using graduated cylinders or bags with manual adjustments to control flow, which were prone to errors and required constant supervision. However, with the development of electronic sensors and microprocessors, automated blood collection monitors have become more sophisticated, incorporating features like touchscreen interfaces, wireless connectivity, and integration with electronic health records.

Overall, the history of blood collection is tied to advancements in medical technology and the use of blood collection monitors has greatly improved the safety and accuracy of this vital process. The blood is collected in flexible plastic bags, ensuring a secure and hygienic storage environment. Blood donation is the process of transferring blood from a donor to a recipient. The blood is collected in flexible plastic bags containing anticoagulants during the process. Anticoagulants are medications used to prevent blood from clotting inside the collection bag during blood donation. This helps to ensure that the collected blood remains in a liquid state, making it easier to separate into its various components for medical use. If blood were to clot, it could lead to inefficiencies in blood processing and potentially reduce the quality of the collected blood components. Anticoagulants are medications used to prevent blood from clotting inside the collection bag during blood donation. This helps to ensure that the collected blood remains in a liquid state, making it easier to separate into its various components for medical use. If blood were to clot, it could lead to inefficiencies in blood processing and potentially reduce the quality of the collected blood components

[2] Literature Survey

Blood collection from donors involves several manual practices. A blood collection bag is attached to the donor via intravenous tubes, and the weight of the bag is measured while blood is being drawn to determine the amount collected. To prevent coagulation and ensure uniform mixing with anticoagulant agents, the blood must be continuously stirred. Several devices are available to fulfill one of these requirements, but few can do both. Some devices use an electrically-driven mechanism to rock the crawl on which the blood bag is placed, while others use a spring or static weighing scale to measure the weight of the blood bag and limit the flow of blood. Blood collection monitors have been developed using various mechanisms to measure the weight of the blood bag and generate electrical power to monitor and terminate blood flow once a certain weight is reached. One patent application describes a blood bag that is suspended from a leaf spring mechanism that measures the weight of the bag. Another monitor uses a balanced fulcrum mechanism attached to a suspended tray that holds the blood bag. The tray is mechanically agitated with the help of an electric motor to shake and mix the blood, while the weight of the bag is periodically measured and the blood flow is terminated before the final weight is reached.

In an International Patent with Application No. PCT/SE2016/050844, JANSSON et al. developed a mechanical and electronic structure comprising a tray that oscillates with the aid

of mechanical arrangement. The shaking moment to the tray is provided for proper mixing of blood, while the tray/cradle is configured to weigh the collected blood. Furthermore, a pump is provided to exert a kneading action on the blood supply tube, safeguarding the return flow of the blood in the blood tubing. Another blood collection monitor by Satoshi Inoue et al. (Appl. No.:445,536) disclosed a technique wherein an electrically operated control device regulates the quantity of blood in a blood container. The blood collector provides continuous or intermittent vibrations by the reference time that corresponds to the blood collection speed and the amount of blood yet to be collected. The collection time not only controls the vibration of the blood container but also halts the action of blood collection.
In another development unveiled in Japanese Patent Publication No. 3153/1976, a blood amassing apparatus for accumulating blood into a blood vessel is wholly electronically driven, gauging the expanse of blood collected in the blood ampoule, intermittently quivered by the pulsating to gather the prerequisite capacity of blood and then restricting the flow at blood to limit or bar the further blood flow within present time as the stipulated quantity of blood collected.

Advanced development in this area is included in an application, Ser. No. 81,164, which is analogous to pondering devices for blood collection bags and to a device that releases energy stored low energy disruption of a magnetic field. The apparatus relies upon the weight of the blood collection bag to anticipate the blood quantification over a record scale. Another form of blood collection device defined in Patent - JP4052407B2 focuses on a blood collection aid with three degrees of freedom rocking motion, a load cell for blood quantification operates on a volt supply by battery or line electricity, vacuum pump to suck and stock the blood in the single entity utilizing external current and voltage source, with total consistent mixing of blood with the aid of electrical supply to anticipate the rocking motion.

Yet another invention, as disclosed in FR2599837A1, puts light on blood rocking, blood quantity measurement, and blood bag fastening methods. It uses the synchronous motor to instigate rolling motion in a blood bag, utilizes an external electrical supply, plank movement for blood anticoagulation initiated by a geared motor consuming direct current from the battery or alternating current from the mainline supply, blood weight analysis is carried out by electromagnetic method, using electrical apparatus to give weight measured output.
Conventional devices are limited to providing the shaking movement to the blood bag, while others only ascertain the weight of the blood collected in the blood bag with the assistance of mechanical mechanisms or electrical means. Devices incorporating both weighing and shaking mechanisms are often bulky in size and expensive. However, the present invention offers a solution to these limitations in the existing system and provides a sustainable substitute against the conventional expensive devices.

[3] Methodology

A rocking motion is a movement that involves a gentle and repetitive back-and-forth motion. This motion can be observed in objects or people that are balanced and swaying, such as a rocking chair or a cradle. It can have a calming and soothing effect in various situations. When it comes to blood collection machines, a rocking motion refers to a controlled tilting or oscillation of the container or device. This motion is used to mix the blood sample with an anticoagulant or additive, preventing clotting or other issues during collection and processing. By gently rocking the container, the blood is thoroughly mixed with necessary substances, maintaining the integrity of the sample for future testing and analysis. Vendel Sramcik presented the use of a pneumatic circuit for providing a rocking motion in his patent. The main purpose of the device is to cool the user of the chair simply and efficiently. The device includes a bellows attachment which utilizes the rocking motion of the chair for causing a continuous draft of air to cool the occupant. The chair also has peculiarly constructed arms with air discharge pipes connected to them, which allow the positions of the discharge mouths of pipes to oscillate. The bellows are actuated alternately by the forwarding and backward rocking motion of the chair through the medium of a device with constant engagement with the supporting surface. The rocking back and forth of the chair will expand and contract the bellows causing the air to be forced out through the nozzles, first on one side of the occupant and then on the other. When it is desired to use the chair without the cooling apparatus being operated, this may be accomplished by disconnecting the belts from the pulleys and then the chair may be rocked ordinarily without any cooling being ejected.

Edwin S. Gaynor presented a study in his patent, Photographic Tray Rocker, a mechanism for the rocking motion of the tray. Paul K. Meeker presented a study in his patent, Powered Rocker Mechanism, using leaf springs, motors, and differently shaped links to provide the rocking motion. This device provides the rocking moment to the chair upon stimulating the motor coupled to the platform. The platform is provided to support the seat for effective chair rocking. An improved rocker assembly comprises a combination of a base having upstanding lateral sidewalls defining an opening therebetween; an intermediate platform positioned within the opening and having an upper region adapted to receive a seat thereon; a U-shaped link means having upper portions supported by the sidewalls, a lower horizontal portion adapted to receive a lower region of the platform thereon, and intermediate vertical portions coupling the upper and lower portions; and drive means coupling the platform and the base for inducing a rocking motion to the platform. This device provides a rocking motion to a swing in a physical space that is smaller than the space required by conventional swings. It also focuses on the device of economical and convenient improved rocking motion for reclining in a conventional seat.

Blood collection or monitoring is a crucial medical procedure that requires careful preparation and execution to ensure patient safety and accurate results. The standard methodology for this process includes several vital steps that healthcare professionals must follow. Here's a general outline of the procedure:

Preparation: Collect all the necessary equipment, including the blood collection device, needles, tubes, antiseptics, and any other required accessories. Verify the patient's information and make sure you have the correct identification to prevent errors.

Patient Preparation: Explain the procedure to the patient, and make sure they understand what will happen. Position the patient comfortably, usually in a sitting or reclined position for blood collection.

Hand Hygiene: Before beginning the procedure, the healthcare professional should practice proper hand hygiene by washing their hands or using hand sanitizer.

Site Preparation: Clean the collection site with an antiseptic to reduce the risk of infection. Allow the antiseptic to dry before proceeding.

Blood Collection: Insert the needle into the selected vein, usually in the arm, using a controlled technique. Collect the required amount of blood into appropriate collection tubes or bags.

Monitoring: If you are using a blood monitor, attach the monitoring device to the patient according to the manufacturer's instructions. Make sure the monitor is calibrated and functioning correctly.

Post-Collection: Remove the needle carefully and apply pressure to the puncture site to stop bleeding. Label blood collection tubes with patient information and the type of test to be conducted.

Blood Sample Handling: Store collected blood samples at the appropriate temperature and conditions to maintain sample integrity.

Transport and Processing: If necessary, transport the blood samples to a laboratory for analysis. Follow specific protocols for processing and testing the samples.

Disposal: Dispose of used needles and other medical waste safely and according to regulations.

Documentation: Record all relevant information accurately, including patient details, time of collection, and any adverse events.

Patient Comfort and Safety: Ensure the patient's comfort and safety throughout the procedure, addressing any discomfort or complications promptly.

It's essential to note that the specific methodology may vary depending on the type of blood collection or monitoring device being used, the purpose of the procedure, and established healthcare protocols and guidelines. Healthcare professionals should always follow industry best practices and manufacturer recommendations to ensure patient safety and the accuracy of collected data.

[4] Feature Blood Collection Monitor BCM 2800

The device has a battery backup that lasts more than 24 hours. It displays measurements in volumes and grams and allows for vibration selection for 3D mixing. The RPM setting ranges from 1 to the specified plate number. It features a large color LCD, auto tare, and manual weight calibration facility. There are audio and video alarms, as well as blood tray tilt angle adjustment and a detachable blood collection tray. The device is password-protected and has tube-sensing capabilities. It is also RS 232 scanner compatible and can store up to 1,000 donor data. The time and data settings can be adjusted and the device can be connected to a computer via USB or RS232. It comes with a carrying case and Blood Bank Management Software. The device can also connect more than the specified plate number via Ethernet to a single PC. An electronic blood collection monitor is designed to accept all types of blood donor bags. It features a D mixing system that ensures efficient blood mixing with anticoagulants. The mixing speed can be adjusted from 1 to 20 rpm, and the tilting angle can be adjusted to a minimum of 10 degrees. The monitor has a large LCD that shows the donation time, collected volume, and average donation fee during blood collection. The volume to be collected can be changed at any time during the donation if desired.

The monitor features an automatic clamp of tubing at the end of the donation with audible and visual alarms. The display shows the final volume collected and the donation time in minutes and seconds at the end of each donation. All collection data can be recalled and read from the memory. The monitor also has an auto-tare of the empty bag and an adjustable upper safety limit for the collected volume. Additionally, the monitor has adjustable Low and High Flow alarms, a detection system on the clamp for checking tube positioning, and a safety switch to control if the tubing is well inserted during the donation if desired. The monitor features an automatic clamp of tubing at the end of the donation with audible and visual alarms. The display shows the final volume collected and the donation time in minutes and seconds at the end of each donation. All collection data can be recalled and read from the memory. The monitor also has an auto-tare of the empty bag and an adjustable upper safety limit for the collected volume.

Additionally, the monitor has adjustable Low and High Flow alarms, a detection system on the clamp for checking tube positioning, and a safety switch to control if the tubing is well inserted into the clamp. It can be easily calibrated within a few seconds with a known calibration mass. The monitor also has an RS 232 port for connecting external equipment such as a barcode reader, and the possibility of connecting to the network through a PC and software. To ensure uninterrupted blood collection, the monitor has a built-in rechargeable battery that can support a minimum of 1000 donations in case of mains failure. It also has an input port cable with 15 Plug and a six-way output terminal strip for two outlets.

BLOOD COLLECTION MONITOR

[5] Specification Of Blood Collection Monitor

The measuring range of the device is from 10 to 3000 ml/gr, and it provides an accuracy of +/-1% or better. The collected volume range is adjustable with 1 ml steps, and two default volumes can be set. The maximum donation time can be adjusted up to 20 minutes, and the data and time can be configured as per your preference. The internal memory can store up to 1000 donations, and service programs are available for common troubleshooting. The calibration mass of 500 grams is supplied along with the device. It operates on 230 Vac, 50Hz power supply with an internal rechargeable battery. The measuring range of the device is from 10 to 3000 ml/gr, and it provides an accuracy of +/-1% or better. The collected volume range is adjustable with 1 ml steps, and two default volumes can be set. The maximum donation time can be adjusted up to 20 minutes, and the data and time can be configured as per your preference. The internal memory can store up to 1000 donations, and service programs are available for common troubleshooting. The calibration mass of 500 grams is supplied along with the device. It operates on 230 Vac, 50Hz power supply with an internal rechargeable battery.

[6] Conclusion

The study proposes a mechanical blood collection monitor which provides a wise solution for the limitations in existing devices. The required oscillation moment for the shaking of the blood bag is obtained by incorporating a mechanical linkage mechanism as well as a gear mechanism. The simulation results obtained from rigid dynamic analysis prove the linkage mechanism to be capable of providing oscillatory movement at a constant rate of one oscillation per 30 seconds. The proposed design was thus found capable of agitating the blood homogeneously thereby preventing the coagulation of the blood. The intermediate gear mechanism was numerically studied using simulation software, ADAMS which suggests the spiral spring can be utilized for storing a significant amount of kinetic energy which further can be utilized for providing rocking motion. Moreover, it was found that the angular velocity is directly in proportion with time and torque. This signifies the constant mechanical output at the final shaft in the mechanism, thereby offering a continuous rocking moment for the required time duration. The mechanically operated blood collection monitoring device thus offers long-term functioning in opposition to traditional electrically aided blood collection monitors, more particularly in large blood collection camps and in rural areas. It can be utilized for long cycle runs with its maximum possible efficiency with the least maintenance of all mechanical components having maximum interchangeability. From the supporting calculations and simulation results, it can be concluded that the mechanical linkage mechanism comprising flat spiral springs, gears, and intermediate mechanisms can be effectively utilized to obtain the desired rocking motion required to prevent blood coagulation. Furthermore, the device can be equipped with a mechanical weighing system to ascertain the amount of blood collected from the donor thereby providing an integrated rocking and quantification system

References

[1] Tuaillon Edouard, Kania Dramane, Pisoni Amandine, Bollore Karine, Taieb Fabien, Ontsira Ngoyi Esther Nina, Schaub Roxane, Plantier Jean-Christophe, Makinson Alain, Van de Perre, Philippe, Dried blood spot tests for the diagnosis and therapeutic monitoring of HIV and viral hepatitis B and C, Front. Microbiol. 11 (2020).

[2] S. Koike, T. Takeda, Experimental Research of Blood Collected from the Peripheral Side of the Fluid Infusion Site That Is Not Affected by Fluid Infusion. Journal of Hematology, North America, 6, mar. 2017. Available <https://www.thejh.org/index.php/jh/article/view/321>. Date accessed: 10 Oct. 2021.

[3] S. Parasuraman, R. Raveendran, R. Kesavan, Blood sample collection in small laboratory animals [published correction appears in J Pharmacol Pharmacother. 2017 Jul-Sep;8(3):153]. J Pharmacol Pharmacother. 2010;1 (2):87-93. doi:10.4103/0976-500X.72350.

[4] Charles Silvers, Precision Cut-Off Weighing Apparatus. U.S. Patent No.39,60,224. U.S. Patent and Trademark Office, 2000.

[5] Per Jansson, Nicklas LUNDMAN. Blood mixer for a blood collection bag. Patent Application No PCT/SE20 16/050844, 2017.

[6] Satoshi Inoue, Fumiaki Inaba. Blood Collecting Apparatus (U.S. Patent No.5153828). U.S. Patent and Trademark Office, 1989.

[7] Masanori Atsushi Nibu Yoshiaki Hirota Isao Taruta Motegi. (2008) Blood collection monitor, 2008.

[8] Luciani Martin, Device for Agitating, Weighing, and Clamping the Blood Bag.Patent No. FR2599837A1, 1986.

[9] Homer M Lindsey, Wilbert D Silva, Blood with Drawing Device. Patent No. US3924700, Worldwide applications, 1974.

[10] Evan W. Rosen, Blood Collection Bag Weighing Device. Patent No. US4390073,1981.

[11] Maxwell Edmund Whisson, Blood Donation Monitoring Means, Patent No.AU683487B2, Worldwide applications, 1994.

[12] Charles Silvers, Precision Cut-Off Weighing Apparatus. Patent No. US3960224.

[13] Johnnie E. Floyd, Blood Mixing and Weight Monitoring Apparatus. Patent No.US4027735, 1976.

[14] Per Jansson, Nicklas Lundman, Patent No. WO2017044040A1, Blood Mixer for A Blood Collecting Bag, 2015.

[15] F. Rossi, B. Castellani, A. Nicolini, Benefits and challenges of mechanical spring systems for energy storage applications, Eng. Procedia 82 (2015) 805–810.

[16] Artur Fischer, Artur Fischer, Power Unit for Toy Building Kit. US Patent Number: 3,484,983. 1969.

[17] Hiroshi Wakase, Takara Co. Ltd., Spring Powered Prime Mover. US Patent Number: 4,478,313. 1984.

[18] J. Tang, Z. Wang, Z. Mi, Y.u. Yang, Finite Element analysis of flat spiral spring on mechanical elastic energy storage technology, Res. J. Appl. Sci., Eng. Technol. 7 (5) (2014) 993–1000.

[19] Vendel Sramcik, Pneumatic attachment for rocking chairs. US Patent Number:1267814. 1918.

[20] Edwin S. Gaynor, Edwin S. Gaynor, Photographic Tray Rocker. US Patent Number 3,998,434. 1976.

[21] Paul K. Meeker, Spalding & Evenflo Companies, Inc. Tampa, Fla., Powered Rocker Mechanism. US Patent Number: 4,911,499. 1990.

[22] PSG Design Data Book, faculty of mechanical engineering, PSG College of Technology, 2000.

[23] V.B. Bhandari, Design of Machine Elements, Tata McGraw Hill Publications, 2009.

[24] In Sang Choi, Blood Glucose Monitoring System, Strip Accommodation DeviceStrip Storage Device, And Automated Blood Collection Device. US Patent Number: US20150190081A1. 2015.

[25] R.E. Ravalika, V. Dharani, N. Lavanya, Beam engine powered punching machine, Int. J. Mech. Eng. Technol. 9 (6) (2018).

[26] P.D. Sonawwanay, A.C. Nemade, S.V. Kulkarni, R.R. Kulkarni, N.S. Patil, Mechanically operated blood collection monitoring device, Indian Patent Application No (2021), 202121017030.