Optimization of Blood Collection through Controlled Tourniquet Pressure: A Qualitative Application Observation to Improve Blood Sample Quality, Reduce Laboratory Costs, and Enhance Patient Treatment Quality

Abstract

The quality of blood samples is crucial for accurate diagnostic results in medical practice. A key factor is the controlled pressure of the tourniquet during blood collection. This qualitative application observation examines the correlation between tourniquet pressure and blood sample quality in 54 subjects. A sensor from Flebotec Medical LTD was used to measure the pressure during sampling. The results indicate that excessively high or low tourniquet pressure can lead to a significant number of unusable blood samples, causing additional costs and delays in patient treatment. Technological solutions, such as automated tourniquets, could help minimize these issues and increase healthcare efficiency.

Keywords: Blood collection, tourniquet, sample quality, blood test, diagnostics, sensor technology, automated tourniquet, medical technology, healthcare, laboratory costs

1. Introduction

Precision in blood collection is a crucial factor for the quality of diagnostic results in medical practice. A common method to facilitate blood collection is the use of a manual tourniquet. Although the tourniquet slows blood flow in the arm veins and simplifies blood collection, the pressure generated can significantly impact the blood sample and lead to distorted blood results.

Impact of Tourniquet Application Duration

Studies show that the duration of tourniquet application significantly influences hemolysis rates. A tourniquet time of less than 60 seconds is recommended to minimize the risk of hemolysis. [1]

Tourniquet Pressure

In the United States, approximately 130 million patients visit emergency departments annually. During these visits, 54 million blood samples are collected, with 30 million undergoing electrolyte analysis (23% of all visits). Blood samples from the emergency department exhibit a particularly high hemolysis rate (6%-30%) . It is essential to use appropriate pressure that slows blood flow just enough to make the vein visible without completely occluding it. Excessive pressure can cause complete vein occlusion at the compression site. Besides hemolysis due to increased intravascular pressure, there is also a risk of coagulation and thrombus formation due to blood stasis. [2-4]

E It is important to use appropriate pressure that slows blood flow just enough to make the vein visible without completely occluding it. Excessive pressure can cause complete vein occlusion at the compression site. Besides hemolysis due to increased intravascular pressure, there is also a risk of coagulation and thrombus formation due to blood stasis. [5]

Sasaki et al. Sasaki et al. recommend a venous cuff pressure of 60 mmHg as standard, noting that venous dilation is greater at 60 mmHg than at 40 mmHg, and this pressure is perceived as less painful than 80 mmHg. The reason medical personnel often misapply the tourniquet is likely their inability to accurately gauge the necessary tension. Thus, developing a tourniquet with markings indicating the correct application pressure is necessary. Sasaki et al.'s study shows that 70% of nurses applied a tourniquet pressure exceeding 100 mmHg.

A properly applied tourniquet can cause the vein's diameter and surface area to swell, making it more visible to medical staff and facilitating the puncture process. According to the Journal of Patient Safety, the basilic vein achieved 65% better visibility, while the median cubital vein became 90%-95% more visible after applying the tourniquet. The cephalic vein's visibility improved by 65%-80%. [6]

Hemolysis Rates

Application observations show that hemolysis is the most common cause of sample rejection in laboratories, accounting for about 60% of rejected samples. [6]

Choice of Puncture Site

The median cubital vein is preferred due to its size and accessibility, though the basilic and cephalic veins can also be used. Vein selection should also consider patient safety, with the cephalic vein deemed safer due to its distance from the median nerve and brachial artery. [6]

This application observation examines the correlation between tourniquet pressure and blood sample quality to highlight the issues of uncontrolled tourniquet pressure and propose solutions.

2. Methodology

For this qualitative application observation, blood samples were collected from 54 randomly selected voluntary subjects. During a routine home visit, medical personnel observed the manual application of the tourniquet. A sensor developed by Flebotec Medical LTD was used to measure and record the tourniquet pressure during application. The quality of the blood samples was then assessed to determine if the laboratory deemed them usable or if they needed to be repeated. The usability of the laboratory results was documented along with the corresponding tourniquet pressure values to analyze the correlation between tourniquet pressure and blood collection quality. The subjects were divided into three groups based on the pressure applied to their upper arm during blood collection:

Group 1: 35-69 mmHg

Group 2: 70-100 mmHg

Group 3: Over 100 mmHg

3. Results

Die The blood collection results show a clear dependence on the applied tourniquet pressure:

Group 1 (35-69 mmHg): 20 good blood samples were obtained from 21 subjects, with only one sample needing repetition, resulting in a repeat rate of approximately 4.8%.

Group 2 (70-100 mmHg): 20 good blood samples were obtained from 28 subjects, with 8 samples needing repetition, resulting in a higher repeat rate of approximately 28.6%.

Group 3 (over 100 mmHg): 3 good blood samples were obtained from 5 subjects, with 2 samples needing repetition, resulting in a significant repeat rate of 40%.

In summary, 11 out of 54 blood samples had to be repeated, resulting in an overall repeat rate of about 20%. Notably, the repeat rate increased with higher tourniquet pressure: while only a few samples needed to be repeated in Group 1, this need increased significantly in Groups 2 and 3. These results underscore the critical role of controlled tourniquet pressure in obtaining high-quality blood samples. Excessive pressure can lead to an increased number of unusable samples, raising costs and delaying patient care. Future approaches should aim to control tourniquet pressure more precisely, such as through automated systems, to improve diagnostic results and reduce the burden on patients and medical staff.

These results demonstrate a clear correlation between higher tourniquet pressure and an increased likelihood of unusable blood samples.

4. Discussion

Issue of Uncontrolled Pressure

Using a manual tourniquet can lead to uncontrolled pressure on the veins, negatively impacting the blood sample. Excessive pressure can cause hemolysis, where red blood cells are destroyed, releasing their contents into the plasma and distorting lab values. This can also result in altered cell concentrations and other blood changes, affecting diagnostic results. This issue often necessitates repeating blood collection, leading to additional costs, inconvenience, and delayed treatment adjustments for patients. Conversely, too low a pressure results in suboptimal visualization of the vessels to be punctured, which is the primary reason for using a tourniquet. The intended swelling of the vein from increased intravascular pressure improves visibility.

Importance of Correct Tourniquet Application

Die Proper tourniquet application is crucial to maintain blood sample integrity. Controlled and optimal pressure can minimize distortions in the blood test, leading to more accurate diagnostic results. This is particularly important for timely and correct patient treatment, as incorrect diagnoses can have severe health consequences. Too low a pressure can also led to more failed attempts due to poor vein visibility.

Reducing Laboratory Costs and Repetitions

The need to repeat blood samples due to poor quality increases laboratory costs and inefficient resource use. Each additional blood collection means more work for medical personnel, more patient discomfort, and delayed therapy initiation or adjustment due to the desired blood values. Introducing technologies that accurately measure and control tourniquet pressure could significantly reduce these repetitions and associated costs. This would not only increase healthcare efficiency but also improve the patient experience by avoiding unnecessary pain and inconvenience.

Technological Solutions: Sensors and Automation

The sensor developed by Flebotec Medical LTD, used in this observation, shows great potential to solve the issue of uncontrolled pressure during blood collection. The sensor measures the tourniquet pressure in real time and records the result for later analysis.

Proposed Solution

Develop and implement an automated tourniquet: Flebotec Medical LTD is developing an automatic tourniquet that can self-regulate pressure and ensure it remains within the optimal range. Such systems would further enhance the consistency and quality of blood samples, reduce the burden on medical staff, and avoid delays. Moreover, the automated tourniquet could regulate pressure automatically, eliminating the need for medical staff intervention. This system could ensure the pressure remains within a safe range, further increasing the consistency and quality of blood samples. This novel technology could be standard in blood collections to improve blood sample quality and reduce the need for repetitions.

Further Research and Development

This study provides a valuable foundation, but further research is needed to determine optimal pressure ranges for different patient groups. Differences in patient age groups may require different tourniquet pressure settings. Long-term studies could help develop more detailed guidelines and refine the technology further.

5. Conclusion

The results of our qualitative application observation highlight the necessity for more precise control of tourniquet pressure during blood collections. Uncontrolled pressure can lead to significant distortions in blood tests, necessitating repeat sampling and additional laboratory costs. Using pressure sensors and training medical personnel offer promising solutions to this problem. Improving blood collection procedures can lead to more accurate diagnoses and optimized patient treatment, ultimately leading to better healthcare.

Referenzen

1. Michael P. Phelan, MD; Edmunds Z. Reineks, MD, PhD; Jesse D. Schold, PhD; Frederic M. Hustey, MD; Janelle Chamberlin, BA; Gary W. Procop, MD – Preanalytic Factors Associated With Hemolysis in Emergency Department Blood Samples. 2018.

2. Heyer NJ, Derzon JH, Winges L, et al. Effectiveness of practices to reduce blood sample hemolysis in EDs: a laboratory medicine best practices systematic review and meta-analysis. Clin Biochem. 2012;45(13–14):1012–1032.

3. Grant MS. The effect of blood drawing techniques and equipment on the hemolysis of ED laboratory blood samples. J Emerg Nurs. 2003;29(2):116–112.

4. Soderberg J, Jonsson PA, Wallin O, Grankvist K, Hultdin J. Haemolysis index—an estimate of preanalytical quality in primary health care. Clin Chem Lab Med. 2009;47(8):940–944.

5. Shinsuke Sasaki, Naoki Murakamia, Yuko Matsumuraa, Mika Ichimuraa, and Masaharu Moric – Relationship between Tourniquet Pressure and a Cross-Section Area of Superficial Vein of Forearm. 2012

6. Kanae Mukai, PhD, RN, Yukari Nakajima, MHS, RN, Tomotaka Nakano, RN, Manami Okuhira, RN, Aya Kasashima, RN, Rina Hayashi, RN, Misaki Yamashita, RN, Tamae Urai, PhD, RN, and Toshio Nakatani, PhD, MD – Safety of Venipuncture Sites at the Cubital Fossa as Assessed by Ultrasonography. J Patient Saf 2020.