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LETTER TO THE EDITOR

Optimizing Blood Culture Volumes by Implementing PDCA Cycle Management

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SUMMARY

Background: **The aim of this study was to optimize the mean volume of blood drawn by nurses to a level that is recommended by our hospital through the implementation of PDCA cycle management. The purpose of the current study was to match the mean volumes of blood drawn with the volume recommended by the manufacturer.**
Methods: **The adequacy of blood volume in a bottle of aerobic blood culture per venipuncture was evaluated for every month from January 2021 to March 2022 by using the Becton Dickinson BD blood volume monitoring system. Furthermore, the study compared changes in the mean blood volumes before and after the PDCA cycle management was implemented.**
Results: **The mean blood volumes calculated for Q1 2021 (January 2021 to March 2021) before the PDCA cycle management was 6.3 mL per culture bottle. After PDCA cycle management was implemented, the mean blood volumes for Q1 2022 (January 2022 to March 2022) were calculated as 8.6 mL ($p < 0.01$). In addition, the positive culture rate increased from 13% to 15%.**
Conclusions: **Implementing the PDCA cycle management can improve the mean blood culture volumes effectively and match the volume recommended by the manufacturer. Additionally, our study indicated that a higher blood volume yielded a culture rate that was significantly positive.**
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Blood culture is important for identifying pathogens and essential for the diagnosis of sepsis. There are many factors that influence the success of a blood culture, including blood collection time, blood sample amount, the number of blood collection sets, and skin disinfection [1]. In fact, the blood volume that was cultured during the detection of bacteremia emerged as a major variable in the detection of bloodstream infections [2-6]. Therefore, an optimal blood sample amount is the most important factor, as the number of microorganisms present in blood can be very low. It is a well-established fact that drawing optimal volumes (8 - 10 mL) of blood for

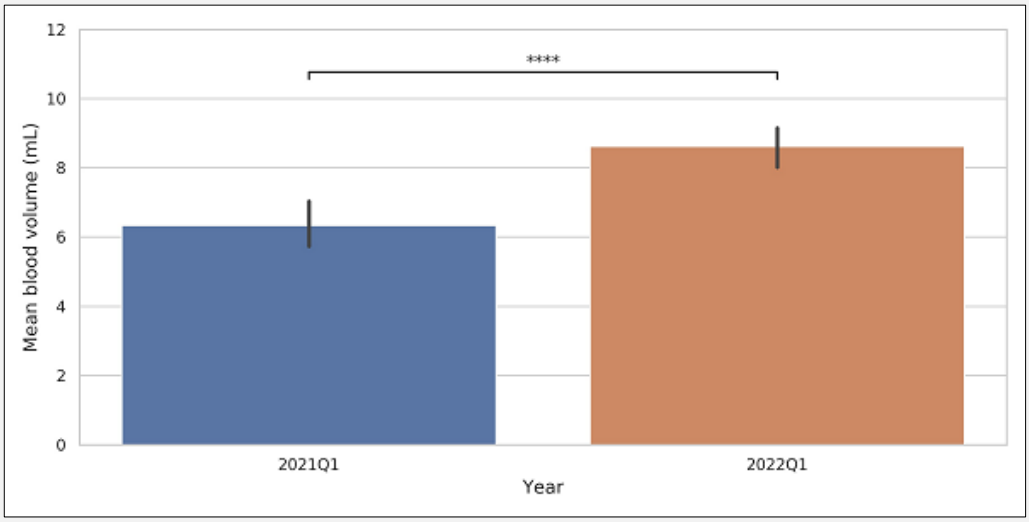

Figure 1. Mean blood volume analysis.

After implementing PDCA cycle management, the mean blood volume increased from 6.3 mL to 8.6 mL.

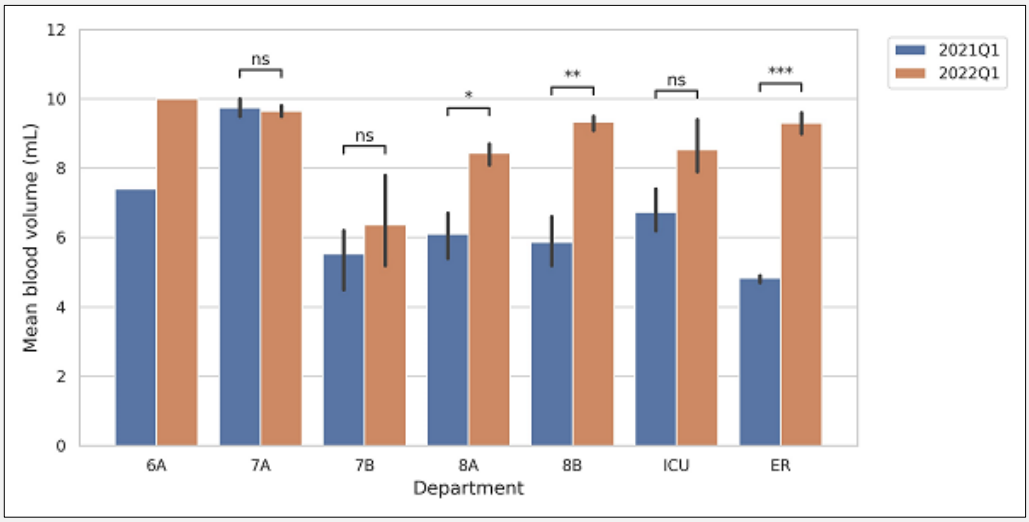

Figure 2. Performance of mean blood volume in each station.

culture boosts the method's sensitivity [6]. Indeed, optimal blood fill volumes critically determine the diagnostic yield of blood cultures. Each mL of blood, up to 10 mL, can increase the sensitivity of the blood culture by 3 - 5% [7,8]. In this study, all of the aerobic bottles were placed into BD BACTEC FX instruments (Becton Dickinson and Co, USA) for blood culture.

The plan-do-check-action (PDCA) cycle management is an effective management tool [9]. The PDCA cycle divides quality management into four stages: plan, do, check, and action. The cycle is also divided into eight steps: (1) raising questions, (2) setting goals, (3) figur-

ing out plans, (4) implementing plans, (5) checking results, (6) discovering problems, (7) solving problems, and (8) proposing new plans or protocols [9,10]. The study aims to explore the effect of the application of the PDCA circulation management mode for improving the mean blood volumes for cultures.

Previously, Lin et al. [11] showed that the average blood volume taken for blood culture is low in a Taiwan hospital, less than 3 mL of blood per bottle for 89.1% of venipunctures. They suggested that the major reason is that one 10 mL syringe can only deliver about 2 - 3 mL of blood into blood culture bottles. Similarly, according to Mermel et al. [7], most US laboratories commonly received blood culture bottles that were inadequately filled from adults, with volumes of less than 5 mL. In our hospital, the main reason for low mean blood volumes for blood culture was insufficient knowledge of the appropriate venipuncture procedure for blood culture. Moreover, no guideline to standardize how blood cultures were handled and inoculated has been introduced. Therefore, the use of online materials or film as a teaching tool was implemented in our hospital. The topics included the importance of obtaining enough blood volume and the appropriate venipuncture procedure. In addition, a pre-test-post-test measurement was also designed to assess the effectiveness of the teaching in this topic. A picture of an appropriate volume for blood culture was created for staff to monitor the volumes collected.

PDCA cycle management aimed to achieve 8 mL to 10 mL of blood for every culture bottle. The adequacy of the blood volume of a bottle of aerobic blood culture per venipuncture was evaluated for every month from January 2021 to March 2022 by using the Becton Dickinson BD blood volume monitoring system. We generated histogram reports for blood volume distribution, summary reports, trending reports, and a monthly blood volume summary. The manufacturer's instructions state to fill each bottle optimally with 8 mL to 10 mL of an adult patient's blood. Statistical change in mean blood volume was analyzed using the Student's *t*-test. After PDCA cycle management was implemented, the nursing station was informed if they failed to meet our targets every month.

A total of 6,131 samples were collected and analyzed. The mean blood volume calculated for Q1 2021 (January 2021 to March 2021) before the implementation of PDCA cycle management was 6.3 mL. After implementing the PDCA cycle, the mean blood volume for Q1 2022 (January 2022 to March 2022) was 8.6 mL, which reflects a statistically significant difference ($p < 0.01$) (Figure 1). Notably, it was found that the mean blood sample volume had increased from 4.8 mL to 9.3 mL in the emergency room (ER unit) (Figure 2). Furthermore, the positive culture rate increased from 13% to 15%.

As mentioned, drawing an optimal volume for blood culture improves the ability to identify pathogens and bloodstream infections and leads to better application of antimicrobials. In summary, our results showed that implementing PDCA cycle management can result in improvements in the mean volume drawn for blood culture and help match the volume recommendations made by the manufacturer.

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Declaration of Interest:
There are no conflicts of interest associated with this paper.

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