An evaluation of automated blood collection mixers

P. F. van der Meer & R. N. Pietersz
Sanquin Blood Bank North-west region, Amsterdam, The Netherlands

**Background and Objectives** We investigated the mixing capacity of two whole blood (WB) collection mixers.

**Materials and Methods** WB was simulated by using a 25% glycerol solution warmed to 35 °C. Citrate–phosphate–dextrose (CPD) anticoagulant of a collection system was stained with toluidine blue, and simulated WB was added at 30, 60 or 90 ml/min, respectively (n = 3 per flow speed). The optical density (OD) of 10-ml fractions was measured, and results are expressed as percentage of a well-mixed '100%-sample'.

**Results** CompoGuard showed adequate mixing at all three flow speeds (average ODs 96–103%). HemoLight showed good mixing at 60 and 90 ml/min (ODs from 97 to 101%). At 30 ml/min, mixing appeared suboptimal, but still conformed to our requirements with ODs from 96% to 104%.

**Conclusion** Both mixers give sufficient mixing of whole blood with anticoagulant.

**Key words:** collection mixers, whole blood.

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Introduction

Mixing of whole blood (WB) with anticoagulant during blood collection is very important to prevent platelet and clotting factor activation. Collection mixers have been developed to automate a number of steps in the blood-collection process. The bags of the blood collection system are placed in the mixer, and once the vein is punctured, the device mixes the blood with the anticoagulant. Both mixers in the study, CompoGuard and HemoLight, measure the flow speed, and can be programmed to sound an alarm when the blood flow falls below a predetermined level. Once the desired volume is collected, the donation tubing is clamped automatically by the mixer to prevent overfilling of the bag. The donation time is automatically recorded. CompoGuard has a barcode scanner, and can record the operator ID as well as WB unit ID (in total up to 30 customer-defined barcodes). Furthermore, CompoGuard has advanced possibilities to programme the mixing movements. From both mixers these data along with mixer ID can be transferred into the blood bank information system.

Because it has been reported that automated blood collection mixers failed to adequately mix simulated WB with anticoagulant [1], we aimed to study the performance of the two recently developed automated mixers as mentioned above at very low, normal and high blood flow rates.

**Materials and methods**

The procedure was done as described in detail by De Korte and Veldman [1]. We used a collection system with inline filter (T3941, Fresenius HemoCare, Emmen-Compascuum, the Netherlands) intended for collection of 500 ± 50 ml WB, which is currently in use in our blood centre. From the system, the 70-ml citrate–phosphate–dextrose (CPD) anticoagulant was removed, and stained with 0·32 mM toluidine blue (T0394, Sigma-Aldrich, Zwijndrecht, the Netherlands). The stained CPD was returned to the collection system. WB was simulated by a 25% glycerol/water solution, and the density was checked by weighing 1 ml, and adjusted to 1·060 g/ml when necessary.

The CompoGuard uses a seesaw tilting movement to mix. It was programmed to not mix during the first 10 second while the scale stands in a 30° angle, allowing the blood to flow under the CPD. Then, the scale was programmed to make two vigorous seesaw movements to mix the two fluids well, followed by seesaw tilting to 15° every 3 second throughout the donation process. The HemoLight uses a continuous
'8-movement' to mix the blood into the anticoagulant; it allows no further programming of the mixing steps.

The glycerol solution was warmed to 35 °C, and connected to tubing of the prepared collection system. The collection system was placed on the mixer, and the fluid was pumped into the system at 30, 60 or 90 ml/min, respectively. A flow speed of 30 ml/min allows collection of 500 ml WB in approximately 15 min, our currently accepted maximum collection time. Normally, a unit WB is collected in 8–9 min, or 60 ml/min. The high flow speed was chosen arbitrarily.

The collection of simulated WB was ended once 500 ml had been added to the system, and the filled collection system was carefully placed upright in a plasma extractor. The tubing was cut, and subsequently 10-ml fractions were collected. Of each fraction, 250 µl was pipetted into a microtitre plate in duplicate. The remainder of all fractions was mixed, and the optical density (OD) of this mixture served as '100% sample'; the glycerol solution served as blank. The OD was measured at 620 nm. The ODs of the fractions were calculated as percentage of the 100% sample as follows:

Fig. 1 Relative optical densities of fractions of mixtures of simulated whole blood in toluidine blue-stained CPD (citrate–phosphate–dextrose), collected using two collection mixers at various flow speeds (mean ± SD, n = 3 per flow speed).
100% × (OD_{fraction} – OD_{blank})/(OD_{100\% \ sample} – OD_{blank}). Each of the flow conditions was studied in triplicate, and results are shown as mean ± SD. We required that the average ODs ranged between 95% and 105% of the 100% sample.

**Results**

The results are summarized in Fig. 1. At all flow speeds, the CompoGuard gave sufficient mixing of the simulated WB with anticoagulant. All fractions had an average relative OD between 96% and 103%.

Both for 60 and 90 ml/min, the HemoLight showed good mixing of the solutions, with ODs between 97% and 101%. Although at 30 ml/min, the figure appears to indicate suboptimal mixing, the average ODs ranged from 96% to 104% (i.e. still within our acceptance criteria).

**Conclusions**

The mixing mechanism of CompoGuard automated blood collection mixer ensures good mixing of anticoagulant with (simulated) WB. The same is true for the HemoLight mixer at normal and high flow speeds. At very low flow speeds, as may happen with the start of blood collection, the simulated WB (density ∼1.06 g/ml) appears to flow under the anticoagulant (density ∼1.01 g/ml) during the collection procedure, resulting in suboptimal mixing with CPD. However, the absolute values still conformed to our requirements. Immediate mixing of the WB with anticoagulant will reduce the difference in density between the two solutions, and enables further mixing of whole blood with anticoagulant. Apparently at very low flow speeds, the thorough seesaw movement of the CompoGuard realizes good mixing.

A previous study by De Korte and Veldman [1], using the same experimental design as us, showed that the collection mixers available at that time almost invariably resulted in poor mixing of simulated WB with anticoagulant. All mixers in their study showed relative ODs as high as 250%, depending on the flow speed studied. Low flow speeds (30–50 ml/min) showed the poorest results. Only manual mixing of the collection containers showed sufficient mixing of WB with anticoagulant. The current study was not intended to compare old vs. new mixers, but the results suggest that the quality of collection mixers has improved over the years.

The investigated mixers were designed to mix whole blood that is collected in systems where CPD is already present in one of the containers. An interesting alternative is adding anticoagulant proportionally to the WB as it is collected. One such system is ABC device [MacoPharma, France] [2]. This device requires a special bag system with an empty collection container and a separate bag for CPD. During collection, CPD is added to the WB with a peristaltic pump, ensuring adequate anticoagulation of WB.

Finally, we used mimicked WB to show mixing with CPD, but it should be reminded that these measurements are only surrogates for platelet and/or clotting factor activation [3].

In conclusion, the two automated collection mixers tested in this study mix anticoagulant with simulated WB well at normal (60 ml/min) and high (90 ml/min) flow speeds. At very low flow speeds (30 ml/min), the CompoGuard mixes well, while mixing with the HemoLight gives variable results.

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**References**