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Brief report

Fluid dispersal from safety cannulas: An in vitro comparative test

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We report a comparative laboratory study between 2 peripheral intravenous catheters equipped with a passive fully automatic safety mechanism to assess generation of blood droplets during withdrawal. One presented no fluid droplets, whereas the other presented droplets in 48% and 60% for the best and worst case, with analysis of variance showing positive effects on the number of droplets generated ($P < .001$). Safety devices can introduce hazards if health care workers are at risk from blood splatter.

Safety devices were designed to protect health care workers from sharps injuries.[1] However, some devices produce blood splatter when their mechanisms are activated,[2-4] resulting in risk for bloodborne infections such as HIV and hepatitis C.[5]

National and international bodies have called for the replacement of traditional devices with safety devices to reduce rates of sharps injuries and related infections.[6-8] Guidelines recommend that risk assessments be done before introducing safety devices into workplaces.[9] Needlestick injuries are dangerous because of the blood load they may contain, and because direct injection into the skin has been shown lead to seroconversion. The fact that there is no evidence that mucocutaneous exposure can lead to seroconversion does not mean there is no risk. There is also no evidence that mucocutaneous exposure does not and cannot lead to seroconversion.

The safety peripheral intravenous catheter (PIVC) market in Europe is 157.67 MM units in 2013 according to Millennium Research Group Inc,[10] and this is expected to grow to 172.74 MM units in 2022, an anticipated market growth rate of 1% over this period. If the risk of mucocutaneous blood exposure with seroconversion is only 1 per million, the human and financial cost of treatment of for these individuals would be significant.

We assessed the potential generation of blood droplets during cannulation needle withdrawal of 2 designs of PIVC device with passive mechanisms used worldwide.[1]

MATERIALS AND METHODS

Study design

Two PIVCs equipped with a passive automatic safety mechanism were examined in a laboratory test during June 2012: Vasofix Safety 20G (B. Braun AG) (PIVC1), and Venflon Pro Safety 20G (Becton Dickinson) (PIVC2). These catheters are among the most used worldwide. The testing was undertaken with 5 angles of assessment (0°, 1°, 2°, 3°, and 4°) and performed based on the best and worst case scenarios described below.

Best case

Best-case scenario simulates the operating theatre anesthetic procedure. An experienced anesthetist in a controlled environment undertakes cannulation, allowing a quick, smooth cannulation that reduces blood movement up the catheter lumen (ie, minimal secondary flashback) and therefore avoids blood contact with the cannula hub before needle withdrawal.

Worst case

Worst-case scenario simulates a cannulation performed by an inexperienced clinician in a busy clinic area. This may prolong the cannulation period and result in blood movement up the catheter into the cannula hub (ie, maximum secondary flashback) and therefore blood contact with the needle during removal.

A total of 200 runs (10 replicates × 5 angles × 2 cases × 2 device types) were performed.

The order of testing was randomized to eliminate systematic effects due to sequence.

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Conflicts of interest: None to report.

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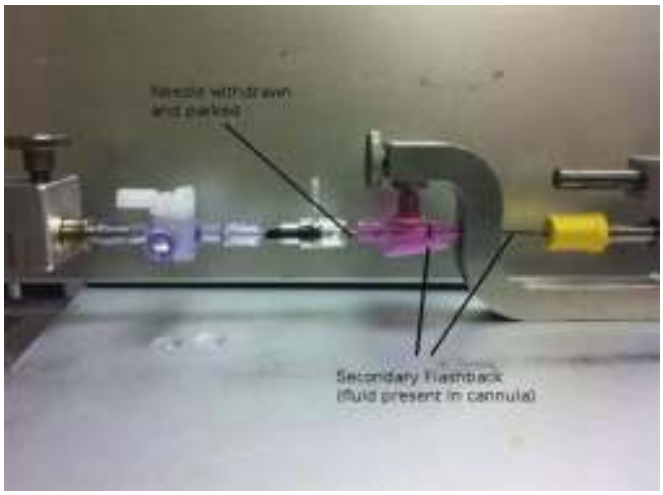

Fig 1. The injection port of the fluid delivery line is manually advanced onto the cannula to a set distance (1 cm from the tip of the cannula needle). This ensures that the cannula is situated at a consistent depth within the fluid line.

Testing details

The safety cannula is inserted into an artificial vein containing a colored blood substitute solution so that flint enters the cannula through the needle lumen into the needle hub (ie, primary flashback). The needle is then slightly withdrawn to allow fluid to enter the catheter lumen (ie, secondary flashback), and then it is fully withdrawn at a consistent speed and specific angle, during which the safety mechanism activates.

Any droplets generated during needle withdrawal and safety mechanism activation are deposited onto photographic paper placed underneath the apparatus. The number of droplets and the distance from the cannula were recorded.

The test apparatus consisted of a central stainless steel assembly that has 2 moveable arms: a fluid delivery arm and a spring-loaded needle holding arm (NHA). Both are able to slide along the central body of the apparatus, which contains a solid pin holding the safety cannula on the apparatus via the cannula port.

The NHA contains a hollow male luer pin, which holds the female luer connector of a cannula needle via a 3-way tap. Adjacent to this is a machined cam, which allows the NHA to be moved horizontally at specific angles relative to the cannula.
The opposite arm contains the fluid delivery line (artificial vein).
At the outlet of the fluid line there is a self-sealing injection port that allows leak-free cannula insertion into the fluid line. See Figures 1 and 2.

Statistical analyses

For detected splatter, statistical analyses were performed using the R statistical package (R Foundation for Statistical Computing, Vienna, Austria), with a generalized linear model constructed with Poisson distribution, including the case effect, the angle effect, and the case:angle interaction, and analysis of variance.

RESULTS

For PIVC2 no fluid droplets were identified at any of the needle withdrawal angles under either the best- or worst-cases scenarios. For PIVC1, mean fluid droplet counts were 0, 0, 3.9, 77.8, and 164 at angles of 0°, 1°, 2°, 3°, and 4°, respectively, for the best case and 0, 1.7, 17.2, 109, and 174 at angles of 0°, 1°, 2°, 3°, and 4°, respectively, for the worst case.

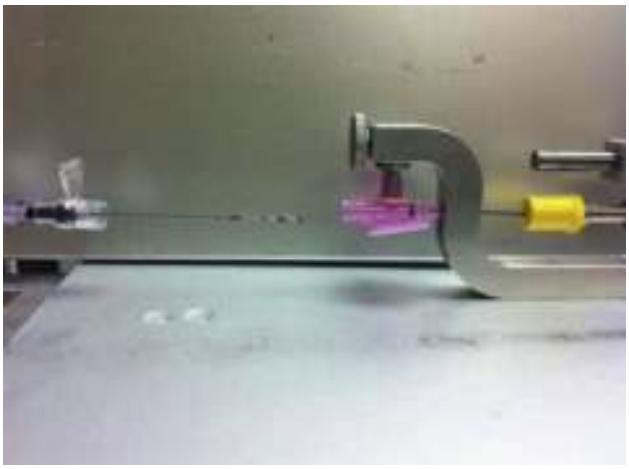

Fig 2. The injection port of the fluid delivery line before being advanced onto the cannula.

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Table 1
Analysis of variance for peripheral intravenous catheter 1

Parameter	Degrees of freedom	Deviance	Residual degrees of freedom	Residual deviance	*P* value*
Angle	1	8,126	98	1,628	<.001
Case	1	57	97	1,571	<.001
Case:angle	1	51	96	1520	<.001

NOTE. For peripheral intravenous catheter 1, a generalized linear model was constructed with Poisson distribution, including the case effect, the angle effect, and the case:angle interaction.
*Greater than χ.

Secondary flashback was faster in PIVC1 compared with PIVC2, resulting in approximate parking times of 4-5 seconds and 1-2 seconds for PIVC1 and PIVC2, respectively.

The frequency and percentage of fluid splatter events for PIVC2 and PIVC1 at each angle under each case showed that no fluid splatter occurred with PIVC2, whereas PIVC1 presented droplets in 48% of experiments (24 out of 50) for the best case, and in 60% of experiments (30 out of 50) for the worst case.

For the best case, the distance range of fluid droplets from PIVC1 was 0-0 cm, 0-0 cm, 2-15 cm, 13-33 cm, and 22-43 cm at angles of 0°, 1°, 2°, 3°, and 4°, respectively, and for the worst case the distance range was 0-0 cm, 3-7 cm, 6-16 cm, 15-29 cm, and 29-41 cm at angles of 0°, 1°, 2°, 3°, and 4°, respectively.

Statistical analyses

No analyses were undertaken for PIVC2 because no splatter was detected under any condition. For PIVC1, analysis of variance shows that both the angle and the case have positive effects on the number of droplets generated, with a significant interaction between angle and case effects. (Table 1)

A 1-sided 2-proportion test was performed for each combination between each device. The results showed PIVC1 had a higher rate of splatter events than PIVC2 at angles of 3° and 4° under the best-case conditions, and at angles of 2°, 3°, and 4° under the worst-case conditions.

DISCUSSION

Our findings suggest that if cannulation needle withdrawal is performed in a straight line (ie, 0°) no blood droplets would be generated, regardless of the amount of blood in contact with the needle. For PIVC2, no droplets were identified under any of the

testing conditions. When PIVC1 is withdrawn at an angle, there is potential for the device to generate blood splatter.

Statistical analysis showed a statistically significant number of droplets were generated with PIVC1 at angles of 3° and 4° in both cases, and at 2° for the worst case. This correlated with the angle of needle withdrawal and the case scenario, meaning a potentially higher infection risk for PIVC1.

CONCLUSIONS

Safety devices need to be evaluated to avoid hazards for health care workers due to blood-splatter risk.[1]

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