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TRANSLATIONAL RESEARCH

Benefits of smart pumps for automated changeovers of vasoactive drug infusion pumps: a quasi-experimental study

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Editor's key points

- Manual changeover of vasoactive drug infusion pumps (CVIP) frequently lead to haemodynamic instability.
- This study demonstrates that smart pumps allowing automated relays decrease both the haemodynamic incident rate and the nursing time dedicated to CVIP compared with manual '*Quick Change*' relays.

Background. Manual changeover of vasoactive drug infusion pumps (CVIP) frequently lead to haemodynamic instability. Some of the newest smart pumps allow automated CVIP. The aim of this study was to compare automated CVIP with manual '*Quick Change*' relays.

Methods. We performed a prospective, quasi-experimental study, in a university-affiliated intensive care unit (ICU). All adult patients receiving continuous i.v. infusion of vasoactive drugs were included. CVIP were successively performed manually (Phase 1) and automatically (Phase 2) during two 6-month periods. The primary endpoint was the frequency of haemodynamic incidents related to the relays, which were defined as variations of mean arterial pressure >15 mm Hg or heart rate >15 bpm. The secondary endpoints were the nursing time dedicated to relays and the number of interruptions in care because of CVIP. A multivariate mixed effects logistic regression was fitted for analytic analysis.

Results. We studied 1329 relays (Phase 1: 681, Phase 2: 648) from 133 patients (Phase 1: 63, Phase 2: 70). Incidents related to CVIP decreased from 137 (20%) in Phase 1 to 73 (11%) in Phase 2 ($P<0.001$). Automated relays were independently associated with a 49% risk reduction of CVIP-induced incidents (adjusted OR=0.51, 95% confidence interval 0.34–0.77, $P=0.001$). Time dedicated to the relays and the number of interruptions in care to manage CVIP were also significantly reduced with automated relays *vs* manual relays ($P=0.001$).

Conclusions. These results demonstrate the benefits of automated CVIP using smart pumps in limiting the frequency of haemodynamic incidents related to relays and in reducing the nursing workload.

Keywords: care workload; critical care nursing; shock; smart pumps; vasoactive drugs

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Continuous administration of short acting and potent medications, such as vasoactive drugs (i.e. catecholamines), during cardiovascular failure is a major challenge in intensive care units (ICUs).[1] In daily clinical practice, vasoactive drugs are administered either with i.v. bag pump systems or syringe pumps. Whatever the device used, flow interruption or undesired bolus doses can severely impact patients. The use of high precision pumps with low compliance infusion devices may prevent most unexpected changes in flow rates during continuous administration of vasopressors and inotropes.[2] This is particularly true with syringe pumps as the volumes of the syringes are relatively small in comparison with bags. As a result, they need to be changed frequently which interrupts the drug's delivery and can lead to haemodynamic instability.[2 3] Moreover, this high-risk period may be time-consuming, depending on the methods of relays.

Various techniques have been described for the changeover of vasoactive infusion pumps (CVIP).[4] In these methods, the CVIP is ordinarily performed manually, which consumes the nursing staff's time and could lead to human errors and, therefore, incidents.[4] Among the common substitution methods for catecholamines, the '*Quick Change*' method, which utilizes two

syringe pumps without an overlapping period, seems as safe as other procedures while minimizing haemodynamic incidents and the nursing staff's workload.[2 5] We previously demonstrated, according to a quality improvement programme, that the '*Quick Change*' method was all the more effective as it was strictly standardized.[2]

In the past few years, new '*smart infusion pumps*' have been designed to secure administration of i.v. drugs.[6] Smart pumps devices, linked to the clinical information system, have drug libraries and features including drug/dose calculations and provide point-of-care decision support feedback for overly high or low i.v. infusion rates and doses.[6 7] Some of the newest smart pumps allow automated syringe relays according to an algorithm derived from the '*Quick Change*' approach. The 'relay function' of these smart pumps, linking two syringes, could limit the interruptions of the flow rate during the CVIP.[8] This programmable method of CVIP may also simplify the work of the bedside nurse.

The objective of the present study was to test the hypothesis that automated relays using smart pumps could limit both haemodynamic incidents and the CVIP-related workload of ICU care providers compared with a standardized '*Quick Change*' method.

Methods

This study was conducted during routine care in a 15-bed university-affiliated adult medical ICU. Ethical approval was obtained from the ethics committee of the Hospices Civils de Lyon. The Institutional Review Board waived the need for consent given the nature of the study. The study was performed in compliance with the ethical standards detailed in the 1964 Declaration of Helsinki and according to the French laws.

Study design

We performed a prospective quasi-experimental study to evaluate the implementation of an automated method for performing relays of syringes with vasoactive drugs in our ICU, according to a quality improvement programme. During the first 6-month period of the study (Phase 1), all CVIP were performed according to the '*Quick Change*' method, whereas, automated relays with smart pumps were used during a second 6-month phase (Phase 2). Haemodynamic incidents and workload related to CVIP were measured in both phases. No change in both the nursing staff and in haemodynamic management for cardiovascular dysfunction occurred during the study period.

Patients

We studied CVIP for all adult patients treated for shock with vasoactive drugs (i.e. norepinephrine, dobutamine, or epinephrine) during the study period. Cardiovascular failure was defined by a mean arterial pressure (MAP) <65 mm Hg, a cardiac output <2.5 litre min^{-1} m^{-2}, or both, with signs of peripheral hypoperfusion despite adequate fluid resuscitation. For these patients, vasopressors, inotropes, or both were required to restore arterial pressure and organ perfusion in accordance with French and international guidelines.[9 10] Patients were continuously monitored, including continuous invasive arterial pressure.

Administration of the vasoactive drugs

All patients who received continuous administration of vasoactive drugs had a multilumen central venous catheter. The proximal lumen was always dedicated to catecholamines and a three-way stopcock was connected to this lumen to perform CVIP. The vasoactive drug's syringes were changed because the volumes of infusion were almost depleted or, under local policy, 24 h had lapsed. Fresenius Vial (Module DPS) syringe pumps (Fresenius Kabi/Vial, Brezins, France) were routinely used in our ICU with 60 ml capacity luer lock BD Plastipack® syringes (BD Plastipack®, Octeville, France). Syringe pumps were connected to a smart pump infusion workstation, Orchestra® Base Intensive (Fresenius, Brezin, France). For each new patient, the name and weight were stored in the database of the infusion device. The nurses had to specify the name (from a library) and concentration of the vasoactive drug when a full syringe was installed on its holder. If the remaining volume in the syringe was <2 ml, a pre-alarm informed nurses that the infusion was ending.

Phase 1: manual '*Quick Change*' relays

During a 6-month period, the CVIP were performed in accordance with our routine clinical practices. Our standardized protocol was continuously available in a specific form in the ICU and all the nurses received refresher courses (1-month period) before the beginning of the study. As previously described, the '*Quick Change*' method consisted of loading the new infusion with a new line into a new syringe pump, containing the drug at the same concentration, and priming the line when the running infusion was about to end.[2] Both syringes were maintained at bed height. Nurses started the (unconnected) pump and chose a high flow rate until a decrease of vasoactive drug appeared at the end of the line, to avoid a start-up delay. Next, they programmed the pump to the same rate and setting as the previous infusion. Then, they removed the cap from the spare port of the three-way stopcock and connected it to the new infusion pump. They next turned the three-way stopcock on to the new infusion, which closed the lumen of the old infusion. Finally, they disconnected the old infusion and put a cap on the spare port.

Phase 2: automated relays

After Phase 1, during a 1-month period, each nurse received a 1-day training course including practical work, to learn the automated two-channel relay. After this training period, all the CVIP were performed automatically over a 6-month period. This modality of automated relay, provided by the smart pump infusion workstation Orchestra® Base Intensive (Fresenius Kabi/Vial, Brezins, France), consisted of two associated channels, which infused the drug one after the other at the same dose. Briefly, up to 4 h before the end of the old infusion, nurses had to select the two-channel relay function of the smart pump and to install the new full syringe (containing