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ORIGINAL ARTICLE

Practical considerations in the administration of intravenous vasoactive drugs in the critical care setting

Part II—How safe is our practice?

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KEYWORDS

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Summary *Introduction:* Vasoactive drugs (e.g. inotropes), namely adrenaline and noradrenaline, are frequently used in critical care to maintain cardiovascular function. This is achieved by ensuring that a continuous infusion of the vasoactive drug is administered so that when one infusion is about to finish another infusion is commenced. This is known as ‘double pumping’ or ‘piggy backing’. Failure to administer these drugs appropriately may result in haemodynamic instability (hypotension and hypertension) and in extreme cases death. *Aims:* The aim of this study was to evaluate current practice and identify the safest method for inotrope administration. *Methods:* A series of three consecutive audits were undertaken to determine which ‘Method’ and ‘Syringe Driver’ were associated with the least adverse effects to patient blood pressure. *Results:* The findings suggest that Modified Method 2, when used in conjunction with a high-risk syringe driver and guidelines, proved to be the safest method for ‘double pumping’ inotrope drugs. Modified Method 2 instructed nurses to: ‘Run both syringe drivers together until a rise in systolic blood pressure is seen (>5 mmHg), then turn the near empty infusion off’. *Conclusion:* As a direct result of these audits, and the development of guidelines, inotrope administration practice on the unit has improved.

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Prelude

Part II of this series follows the literature review undertaken by Trim and Roe (2004) ‘Practical consideration in the administration of intravenous

vasoactive drugs in the critical care setting: the double pumping or piggyback technique’.

Introduction

Vasoactive drugs (e.g. inotropes), namely adrenaline and noradrenaline, are frequently used in critical care to maintain cardiovascular function. This is achieved by ensuring that a continuous infusion of the vasoactive drug is administered so that when one infusion is about to finish another infusion is

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commenced. This is known as 'double pumping' or 'piggy backing' (Crisp, 2002). Failure to "double pump" successfully and safely can cause interrupted flow of the drug, resulting in haemodynamic instability (hypotension and hypertension) and in extreme cases cardiac arrest. Furthermore, the practice of giving a bolus during this procedure can precipitate further cardiovascular instability. Despite these potentially serious complications there appears to be a fundamental lack of evidence regarding current practices and safe administration of inotrope drugs (Trim and Roe, 2004).

Crisp (2002) surveyed 'piggybacking' or 'double pumping' techniques in several Intensive Care Units (ICU's) across the UK using questionnaires. The most frequent techniques reported by the nurses involved an overlap in the running of the infusions. Variations in start up delay and discontinuation rates were also reported. The methods reported by Crisp (2002) were:

1. Start the new infusion at a low rate and titrate it upwards while the old infusion is titrated downwards.
2. Start the new infusion at the same rate as the previous infusion and titrate the old infusion downwards.
3. Start the new infusion at the same rate as the previous infusion and stop the old infusion immediately.

However, it is important to note that no attempt was made to evaluate the effectiveness of these methods or their effect on the patients' physiological parameters. In addition, only 21% of the ICU's surveyed reported using protocols or guidelines for inotrope administration and 'double pumping'.

Other variables thought to influence the efficacy of vasoactive drug administration are:

1. The nurses' level of experience, competence and training (Crisp, 2002; Quinn, 2000; Trim and Roe, 2004; Whyte, 2001).
2. The type of syringe driver used. A 'high risk' syringe driver specifically designed to administer 'high risk' drugs with greater precision is recommended. These characteristically have a minimal start up delay and a sensitive occlusion alarm (Trim and Roe, 2004).
3. The location of the syringe drivers at the bedside. They should be positioned together (i.e. one above the other) and at bed height on the drip stand to prevent siphoning (Amoore and Adamsom, 2003; Trim and Roe, 2004).
4. Accurate record keeping detailing the patients' previous response to the syringe change and methods used.

5. The use of protocols and guidelines to regulate inotrope administration.

To evaluate current practice and identify the safest method for inotrope administration a series of three consecutive audits were undertaken. This first audit identifies current practices within the Intensive Care Unit (ICU). Information obtained from this audit enabled guidelines to be implemented to govern syringe change techniques. A re-audit was then performed to evaluate the impact of the guidelines. A second re-audit was then undertaken to identify the safest syringe change method. The guidelines were then re-modified accordingly.

Infusing inotropes: initial audit

Aims

The aim of the initial audit was to identify:

1. The methods used during syringe changes.
2. The type of syringe drivers used to administer vasoactive drugs.
3. The haemodynamic responses to syringe changes (i.e. blood pressure).
4. The location of the syringe drivers at the bedside (i.e. one above the other).

Method

This audit was undertaken in an 17-bedded adult intensive care unit in a London teaching hospital over a 2-week-period (June 2002). Nurses were asked to complete an audit form each time a syringe change was necessary. Details requested included the syringe change method, the type of syringe drivers used and their location at the bedside (i.e. were the syringes located together on the drip stand). The nurses were also asked to document any changes to the patient blood pressure during the syringe change. The audit forms were anonymous.

Results

A total of 24 syringe changes were audited and three syringe change methods were identified (Table 1).

Method 1 was used three times (12.5%), Method 2 nine times (37.5%) and Method 3 twelve times (50%). All syringe change methods resulted in incidences of adverse effects to the patients' blood pressure (as defined by a blood pressure increase or decrease of more than 30 mmHg) as shown in Fig. 1.

The audit identified three main types of syringe drivers used to administer the vasoactive drugs (Table 2).

Table 1 Syringe change methods.

Method	Syringe change method
1	Start the second syringe driver then immediately turn off the first infusion
2	Run both syringe drivers together for a period of time then turn off the first infusion
3	Run both syringe drivers together at the same rate then titrate down the first infusion

Table 2 Syringe drivers used.

Syringe driver code	Model of syringe driver
1	Asena-Alaris ^R
2	Grasby ^R 3400
3	Grasby ^R 3500

Syringe Driver 1 was used seventeen times (70.8%) and Syringe Driver 2 five times (20.8%). A third type of syringe driver, Syringe Driver 3 was used only twice (8.3%). The haemodynamic effects

associated with each syringe driver, during syringe changes were also reported (Fig. 2).

Although Syringe Driver 3 appears to perform very well, it must be noted that this was only used twice and as such its performance in relation to frequency is questionable.

With regard to the positioning of the syringe drivers 79.2% ($n = 19$) were located together on

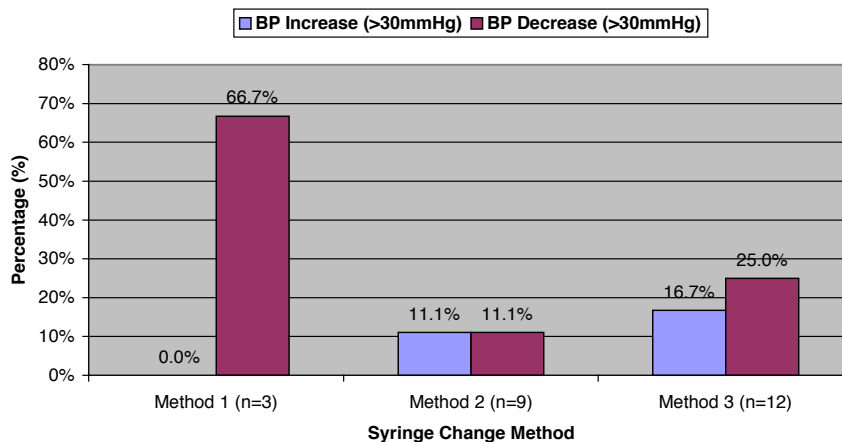


Figure 1 Haemodynamic effect associated with each syringe change method.

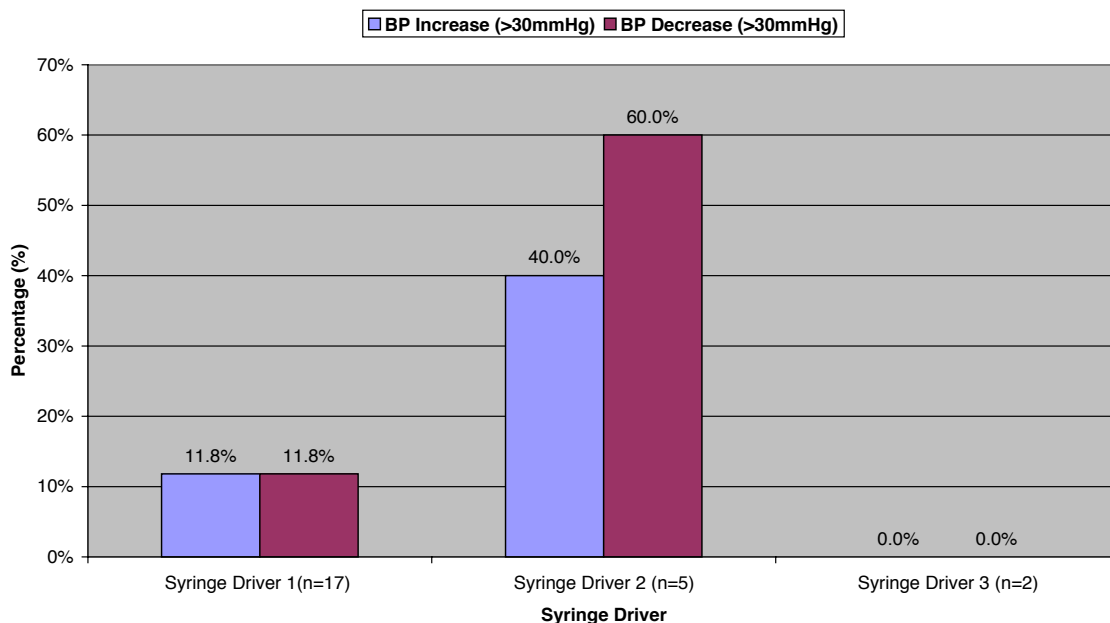


Figure 2 Haemodynamic effect associated with each syringe driver during syringe changes.

the drip stand (i.e. one above the other). This arrangement of syringe drivers was associated with fewer adverse effects to blood pressure. Administering a bolus of drug during the syringe change procedure occurred in 4.2% ($n = 1$) of cases.

Discussion

All 'double pumping' methods had an adverse effect on the patients' blood pressure. However, Method 2 demonstrated the least incidence of adverse effects in relation to frequency of use. It was interesting to note that this method was not the most frequently used syringe change method.

Of the three syringe drivers used to administer the inotropes, Syringe Driver 1 had the least adverse effects in relation to frequency of use. A possible explanation for this was that Syringe Driver 1 was a 'high-risk' device and as such is widely regarded as giving the most accurate and consistent flow pressures (Auty, 1995).

The administration of a bolus was not commonly performed ($n = 1$). Methods involving titration of infusion rates were associated (on occasions) with extreme variations in patient blood pressure, which resulted in the administration of a bolus. For instance, during one syringe change (involving Method 3 and Syringe Driver 2) the patient's systolic pressure dropped from 100 to 45 mmHg and a bolus of inotrope was given. This resulted in a rise in systolic blood pressure to 220 mmHg. As noted previously, bolusing of an inotrope (unless in an arrest situation) may lead to further haemodynamic instability as demonstrated by this event. During the same procedure it was also noted that the pumps were not located together. Thereby necessitating the nurse to move around the bed area to adjust the infusion rates. This may have further contributed to this adverse event.

As a result of this audit, guidelines were introduced to govern practice on the unit. These recommended the use of Method 2 (i.e. Run both syringe drivers together for a period of time then turn off the first infusion.) in conjunction with Syringe Driver 1.

Re-audit (1)

Aim

The aim of this re-audit was to evaluate the impact of the inotrope guidelines on clinical practice.

Method

The re-audit was repeated 3 months after the introduction of the Inotrope Guideline in December 2003. Data was collected over a 2-week period and a similar audit form used. Once again nurses at the bedside were asked to complete the audit form after every inotrope syringe change.

Results

A total of 26 syringe changes were audited during this time and two syringe change methods were described: Method 2 ($n = 16$) and 3 ($n = 10$). However, it was encouraging to discover that Syringe Driver 1 was used on all occasions and all syringe drivers were located together on the single drip stand (i.e. one above the other).

A significant change in systolic blood pressure ($>$ or <30 mmHg) was noted in 18.8% ($n = 3$) of the syringe changes for Method 2 and 50% ($n = 5$) of the syringe changes for Method 3.

Discussion

When used correctly the recommended method, Method 2, proved to be associated with the least number of adverse effects to blood pressure. However, it is important to note that the guidelines were not being adhered to, as alternative methods were still apparent. For example, the speed at which syringe drivers were titrated upwards or downwards varied between syringe changes.

There was also an issue relating to Method 2 because the 'period of time' chosen to run the syringe drivers together was at the discretion of the individual nurse. This made it very difficult to accurately ascertain the reason for blood pressure differences between the methods. As such the methods were adapted to specify the point at which the near empty infusion was stopped: '*Run both syringe driver together until a rise in*

Table 3 Modified syringe change method.

Modified Method 2	Method 2—Run both syringe drivers together until a rise in systolic blood pressure (>5 mmHg) is seen, then turn the near empty infusion off
Modified Method 3	Method 3—Run both syringe drivers together until a rise in systolic blood pressure (>5 mmHg) is seen, then titrate down the old infusion according to the patient's blood pressure

systolic blood pressure is seen (>5 mmHg)' then either 'turn the near empty syringe off' (Modified Method 2, Table 3) or 'titrate down the near empty infusion according to the patients blood pressure' (Modified Method 3, Table 3).

Re-audit (2)

Aim

The aim of this re-audit was to evaluate the two modified syringe change methods and identify the safest method.

Method

This project was undertaken over a 2 week period in May 2003. Syringe changes were undertaken using Modified Methods 2 or 3 (Table 3). To provide greater guidance these methods specify when infusions should be stopped.

This audit differed slightly from the previous two because in this instance the nurses were told which method to use. As soon as a patient was commenced on inotropes the nurse at the bedside was asked to select a sealed envelope. The envelopes contained syringe change guidelines for Modified Methods 2 or 3. Each time a syringe change was required the selected modified syringe change method was used. Nurses were asked to document the patient's blood pressure before and after 'double pumping'. The guideline also stated that high-risk syringe drivers should be used and that syringe drivers should be located together on the drip stand. Ethical approval

was obtained from the Hospitals Local Ethics Committee for this part of the audit. Once again the audit forms were anonymous.

Results

A total of 33 syringe changes were assessed, 19 for Modified Method 2 and 14 for Modified Method 3. A significant change in systolic blood pressure ($>$ or <30 mmHg) was noted in 15.8% ($n = 3$) of the syringe changes for Modified Method 2 and 35.7% ($n = 5$) of the syringe changes for Modified Method 3 (Fig. 3).

Discussion

The findings suggests that Modified Method 2, when used in conjunction with a high-risk syringe driver and guidelines, was associated with the least adverse effects to blood pressure and as such proved to be the safest method for the 'double pumping' inotrope drugs. Modified Method 2:

'Run both syringe drivers together until a rise in systolic blood pressure is seen (>5 mmHg), then turn the near empty infusion off'.

High Risk syringe drivers are thought to be associated with fewer adverse effects to patient blood pressure because they are designed to limit the time delay before the drug is delivered (Fox, 2000). The delay, due to 'mechanical slack' causes a time of variable delivery at the onset of the infusion irrespective of the set flow rate. According to Amoores et al. (2001) it is this variability that would necessitate a period of titration. To further minimise

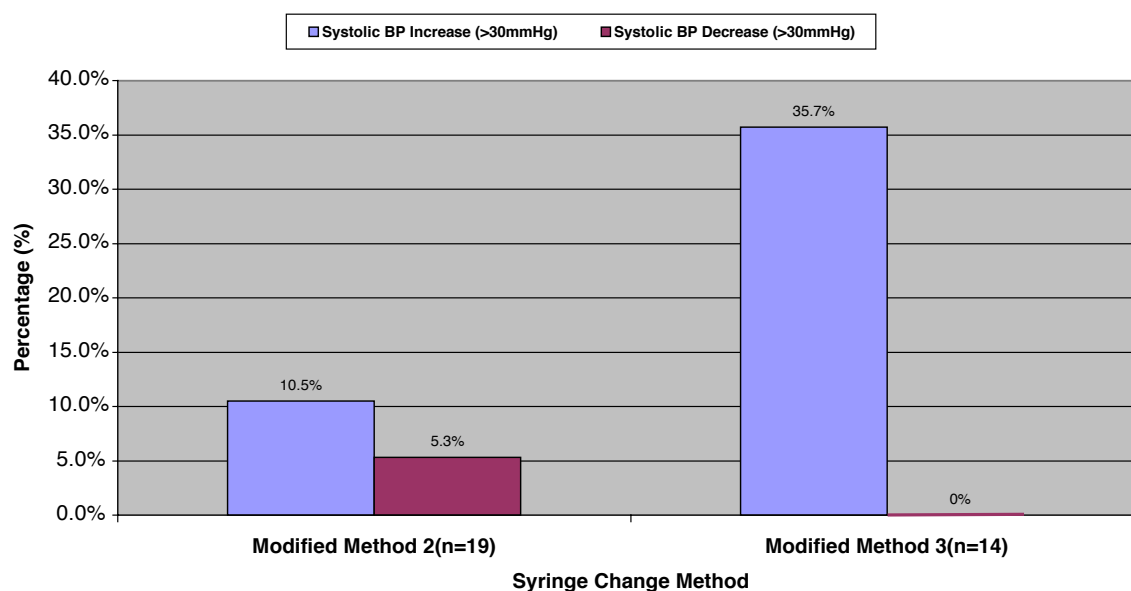


Figure 3 Effects to systolic blood pressure during syringe changes.

the risk of start up delay the literature (Amoore and Adamsom, 2003; Amoore et al., 2001; Medical Devices Agency, 1998; Quinn, 2000) recommends that infusion lines should be fully primed before the syringe is attached to the patient. This can be achieved by depressing the syringe driver priming button until the entire infusion line is filled with the drug.

It is important to note that since the audit forms were anonymous it was impossible to identify the nurses' level of competence or experience. As such these variables may have influenced the efficacy of the drug administration (Trim and Roe, 2004). However, it could also be argued that had the audit forms not been anonymous nurses may not have been so honest for fear of repercussions. Nonetheless, together with the sample size, this is an acknowledged limitation of the study. It is also

important to note that re-audit (2), may be more accurately defined as a comparative evaluation (Ovretveit, 2003). However, the title 're-audit (2)' was adopted to maintain consistency in reporting.

Future studies are recommended and include conducting a large-scale audit over a longer period of time. Conducting audits in other clinical areas, e.g. Paediatric Intensive Care, Accident & Emergency, and Theatres. Finally, since this audit focused on nurses practices rather than demographic variables it is recommended that a further study be undertaken to investigate nurses' knowledge, practice and rationalization for actions. This multi-method triangulation approach can be undertaken by observing the nurses practice, interviewing them about their practice, and finally assessing their understanding of infusions and double pumping using knowledge based questionnaires. This

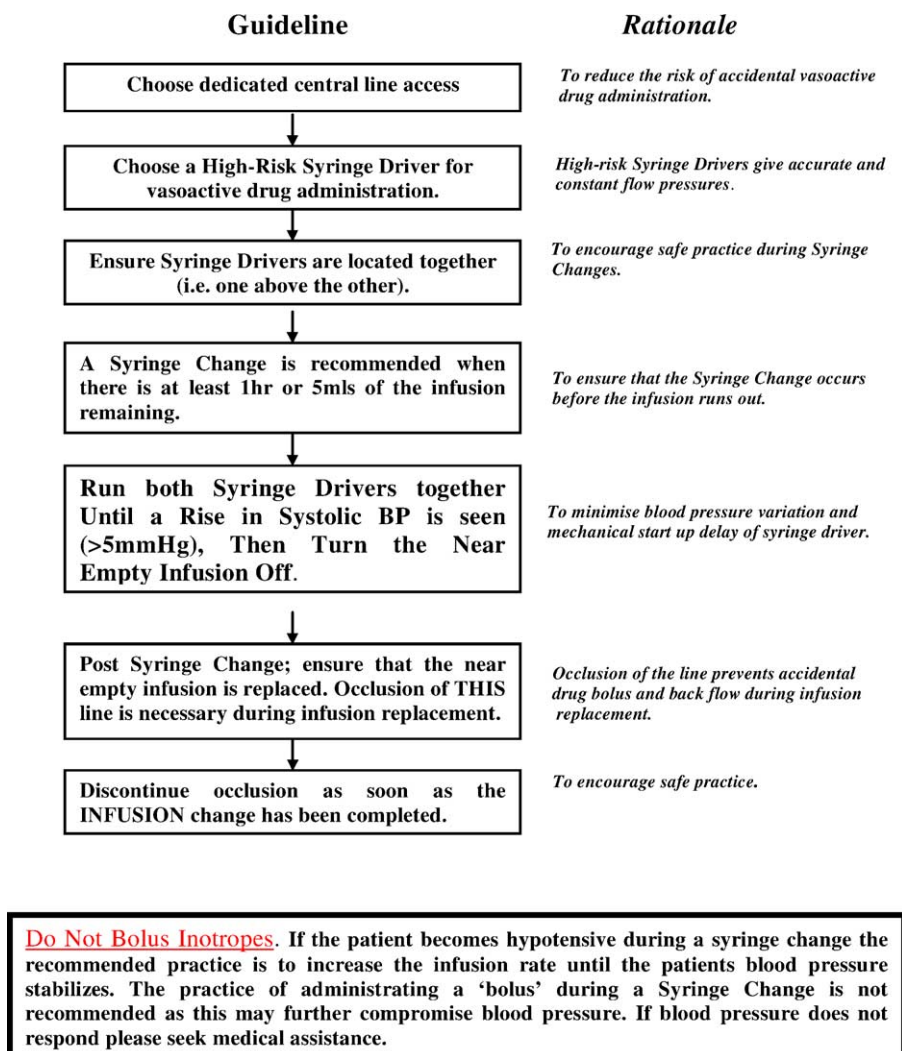


Figure 4 Guidelines for noradrenaline and adrenaline syringe changes (Critical Care Unit, St. George's Healthcare NHS Trust).

method of triangulation has been successfully used in other research studies (Day et al., 2002) and goes some way to explain discrepancies between knowledge and practice (Norman et al., 1992).

Conclusions

This audit although limited by its sample size provides important information as to the current practices surrounding inotrope administration and the potential consequences of these practices. Furthermore this audit highlights just how important it is to review current practice in the clinical area.

As a direct result of these audits, and the development of guidelines, inotrope administration practice on the unit has improved. Nurses are now using 'high risk' syringe drivers to administer vasoactive drugs and these syringe drivers are located together on the drip stand (i.e. one above the other). More importantly the nurses have used the guidelines to inform their practice and as such are using Modified Method 2 during syringe changes. By promoting safe inotrope administration and reducing the number of adverse effects associated with syringe changes this will ultimately improve the quality of care patients receive.

Recommendations for the administration of inotropes

- To minimise the mechanical 'start up delay' ensure that the infusion lines are primed. Do not attach the syringe to the patient until the infusion lines have been fully primed. This can be done by depressing the syringe driver priming button until the entire infusion line is filled with the drug.
- Modified Method 2 is the recommended syringe change method: *'Run both syringe drivers together until a rise in systolic blood pressure is seen (>5 mmHg), then turn the near empty infusion off'*.
- To ensure that accurate and consistent flow pressures use a 'high risk' syringe driver, (e.g. Asena-Alaris^R) to administer vasoactive drugs.
- To prevent siphoning ensure that the syringe drivers are at bed height.
- To encourage safe practice ensure that the syringe drivers are located together on the drip stand (i.e. one above the other).
- To ensure the safe administration of inotrope drugs guidelines are recommended (Fig. 4).
- If the concentration of the infusion is changed, i.e. from 10 to 5 mg strength, the infusion line must be changed.
- If the patient becomes hypotensive during a syringe change the recommended practice is to increase the infusion rate until the patients' blood pressure stabilizes. The practice of administering a 'bolus' (unless in a cardiopulmonary arrest situation) is not recommended as this may further compromise the patient.

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