Needleless Intravascular Access

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Abstract
Healthcare workers (HCWs) are at risk for needlestick injuries (NSIs), and in the modern context infections acquired in this manner may have life-threatening sequelae.
HCWs often do not report NSIs and this may explain the apathetic attitude that some authorities have adopted, regarding safer "needleless" systems in operating theatres.
Completely "needleless" theatre environments can cause a dramatic escalation in costs. However, cheaper options such as drugs in plastic ampoules, blunt drawing-up needles, and three-way stopcocks for administration of drugs, although preventing injury to the HCW, are less effective in preventing contaminated injuries. The combination of the more expensive Engineered Sharps Injury Prevention Devices (ESIPDs), Needleless Intermittent Intravenous-access Systems (NIIS) *, and accessible at-hand sharps disposal bins, should also be available, since these decrease the incidence of percutaneous transmission of infection. It is the responsibility of each anaesthetist to insist that these items are always readily available.*
** ESIPDs : intravenous catheters with introducer needles with built-in safeguarded mechanisms.*
** NIIS : An example would be needle free fluid administration sets.*

Key words: *Needlestick injuries, Engineered Sharps Injury Prevention Devices, Needleless Intermittent Intravenous-access Systems, Disposal bins.*

Introduction

As the pandemic of Human Immunodeficiency Virus (HIV) and other communicable diseases escalates in Sub-Saharan Africa, it is time that South African health care workers (HCWs) assume responsibility for their own personal safety and take authorities to task to ensure safer working environments. Cost constraints may not be the only factor that is retarding this process, but apathy and acceptance of sub-optimal standards by HCWs are also important factors. In this article, an attempt will be made to highlight the issues that are important in developing safer systems in South African operating theatres. It is essential that hospital administrators and institutions understand that the entire process, from drawing up the drug to injecting it into the patient, has to be made hazard-free. For example, open wounds on hands, acquired from the opening of glass ampoules, may be an important port of infection. It would therefore be of little value to concentrate only on the acquisition of a single disposable item such as a safety intravenous catheter.

Australia was the forerunner in attempting to remove all sharp or potentially hazardous articles from the operating theatre. The concern in Australia is not HIV. transmission. Only 37 cases of HIV infection were reported in the entire Southern Australian region for 2002-2003. Compared with the estimated 4.7million HIV positive cases in South Africa at the end of 2001[1], this figure is negligible and would not have warranted such a drive to prevent NSI. Hepatitis C (HCV) is the main concern of the Australian authorities. This virus is much hardier than HIV, with a ten times higher needlestick seroconversion rate and no effective available prophylaxis (Table I,section 4). If the seroconversion rate from a hollow-bore blood filled needle for HIV is 0,55%, i.e. 1 per 182 needlesticks[2], then the rate for Hepatitis C will be 1 in 18.

In the 1980's, Australia was the first country to advocate the use of plastic ampoules, and soon a prototype was developed whereby the drug could be withdrawn directly from the ampoule

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Table I: South African Hazardous Biological Safety Regulation Classification

Class	*Potential for harm*
1	Unlikely to cause human disease
2	• May cause human disease in that it is a hazard to exposed persons • Unlikely to spread to the community • There is effective prophylaxis and treatment. Examples: helicobacter pylori, campylobacter and clostridium
3	• May cause severe human disease in that it poses a serious hazard to exposed persons • There is risk of spread to the community • But effective prophylaxis and treatment is available Examples: Mycobacterium Tuberculosis, hepatitis B, D, E, HIV, plasmodium falciparum
4	• Causes severe human disease, with serious hazard to exposed person • High risk of spread to the community • No effective prophylaxis or treatment Examples: Haemorrhagic fevers, Hepatitis C

without using a needle (Figure 1a). Today Australian theatres are almost completely "needleless", using comprehensive systems such as the Interlink® system (see below) in conjunction with plastic ampoules, and very stringent waste disposal protocols.

In the USA, the Occupational Safety and Health Administration (OSHA) revised the Bloodborne Pathogen Standard and in 2001, began enforcing the use of appropriate and effective sharps devices with engineered sharps-injury protection.[3]

Figure 1a: Drugs packaged in plastic ampoules as available in Australia

Factors that may decrease sharps injuries in South African theatres

Any attempt to introduce a safer system in theatre has to take the entire process into account – from drawing up a drug to the final administration. Every step has to be analysed and made needle- and sharps-free.

Aspects that should be targeted to promote safer systems in theatre are:

- Plastic ampoules
- Blunt drawing-up needles
- Disposal bins
- Engineered Sharps Injury Prevention Devices (ESIPDs)
- Needleless Intermittent Intravenous –access systems for peripheral infusions (NIIS)

Figure 1b: The syringe fits directly into the opening of the ampoule

Plastic ampoules

A survey amongst anaesthetists at Pretoria Academic Hospital revealed that the commonest cause of trauma to fingers in theatre is the opening of glass ampoules. In South Africa, a plastic ampoule of atropine, for example, is cheaper than a glass ampoule. The ideal situation would be to have all ampoules in theatre made of plastic and an even better solution would be ampoules allowing the syringe to fit directly onto the opening of the ampoule, facilitating withdrawal of the drug without a needle (Figure 1b). The distribution of all drugs in plastic ampoules may not be economically viable for pharmaceutical companies, and drug incompatibility in polyvinyl carbon (PVC) containers may also be a limiting factor.

Nevertheless, the use of plastic ampoules in theatre should be advocated where possible.

Hollow needles

Hollow needles are used to draw up drugs, to inject into administration ports, and are also the introducer needle inside intravascular catheters. The introducer needles for vascular catheters cause the most concern, as they are filled with blood after insertion into a vessel.

a) Drawing-up needles

Traditionally, theatres have been stocked with sharp needles to draw up drugs from ampoules. Logic dictates that if one has to withdraw the drug from an ampoule then a blunt needle will work just as well. Although blunt needles are more expensive, the actual price difference is minimal. Only one size of blunt needle would be required, and size 18G could be the needle of choice.

Furthermore, blunt plastic cannulae are available that can be inserted through virtually all intact standard rubber vial membranes or standard Y-ports to allow IV access, but these cannulae may not be available in South Africa.[20]

b) Intravenous catheters: Engineered Sharps Injury Prevention Devices (ESIPDs) (Needles with safeguarded mechanisms, self capping catheters)

Introducer needles inside intravenous (IV) catheters are a major cause of needlestick injuries. An analysis of the causes of percutaneous injuries from hollow-bore needles, shows that 56% occurred during or after the removal of the introducer needle from the IV catheter.[1] (Table II). Attempts have been made to produce safety-engineered sharps devices around- or in these needles to sheath the hollow-bore, now blood filled sharp needle, on withdrawal from the IV catheter in the vein. The earlier prototypes of these intravenous safety catheters were technically difficult to

Table II: Causes of percutaneous injuries with hollow-bore needle (adapted from NIOSH 1999)

Cause	*% responsible for injury*
Cannulation	8
Passing device after use	10
Recapping	5
Clean-up	11
Collision with healthcare worker	8
Disposal	22
Manipulating needle	27
Other	9

insert[18,19], but more recent models are much improved and the technical aspect should not be a major concern. Objection to such needles may now only be the cost.

Disposal bins

As IV catheters fitted with safety devices are not universally available in theatre complexes, the next logical step would be the safe disposal of sharps. Table 2 illustrates that disposal of cannulae are responsible for 22% of NSIs.

Many NSIs occur because the person inserting the catheter has no choice but to put the needle down, as the sharps bin is a long way from the site of insertion. The only other alternative is to pass the needle to the anaesthetic assistant or recap it. In total this is can account for up to 56% of the injuries (Table II).

Disposal bins are traditionally placed on or above the drug trolley to enable the doctor to dispose of opened glass ampoules conveniently. (Figure 2a and 2b).

A simple solution would be to have the disposable bin at the site where the intravenous catheter is being inserted. This second sharps bin should either be a small container (Figure 3a and b), or a metal frame should be added to a small trolley placed next to the anaesthetist and a sharps bin inserted in this frame.

However, some studies have not shown that in-room needle

Figures 3a and 3b: sharps container at hand (Courtesy of Queen Elizabeth hospital, Adelaide, South Australia)

Figure 3a: Close-up of Intravenous cannulation tray

Figure 3b: Disposal bin at hand during intravenous cannulation

Figures 2a and 2b: Position of sharps disposal bin in 2 Gauteng theatres

Figure 2a. Private hospital

Figure 2b. Provincial hospital

box containers have been associated with a reduction in the number of injuries related to sharps disposal.[12,16]

Disposable bins should be rigid (polypropylene), puncture resistant[17], and should also not be overfilled (Figure 4). The "straight-drop" system allows staff to deposit more needles into a full box, resulting in needlestick injuries. A sharps container should not be filled to more than 75% of the entire volume.[15]

Figure 4: Overfilled sharps disposal bin

Needleless Intermittent Intravenous-access Systems for peripheral infusions (fluid administration sets)

NSIs may occur when sharp needles are inserted into a port of an administration set. To obviate this problem, at least 2 needleless intermittent intravenous-access systems for peripheral infusions systems have been developed. Common systems (Figures 5a and b) are:

a) The Clave®- type system. This is a system, in use in South Africa, whereby a syringe is directly introduced into a rubberised port in an infusion line.
b) The Interlink® -type system. In this case, a special blunt-tipped plastic needle fits into a rubber port added to a fluid administration set.

Concerns relating to the use of these ports are:

- Introduction of infection. In practice, this has not been shown to be a significant problem.[6,9] Cleaning the port with alcohol swabs is advocated for infection control.[10,11] Traditional 3-way stopcocks are known to develop bacterial and fungal contamination with longterm use.[14]
- Increased risk of air embolism.
- Increased dead space.
- Delays with drug delivery.
- Inability to use effectively with one hand.
- The system, as well as the Luer lock syringes which should be used with the Clave®, is more expensive.

But do these systems prevent NSIs? Logic dictates that if sharp objects are completely removed from a system then less injury should occur.

The OSHA cautions employers not to calculate injury rate when comparing the effectiveness of safety devices. This is because a sufficient sample size to allow a valid comparison of safety devices, based on injury rates, is rarely feasible in a single facility outside formal research trials.[7] A review of the literature illustrates this problem in that many studies[4,5] have shown no statistically significant differences in the incidence of NSIs with the use of NIIS. Nevertheless, several investigations suggest that these systems are not only extremely effective in reducing intravenous line-related NSIs, but also pay for themselves.[8,9]

Figure 5a: Unassembled systems
A: Interlink® needle and bung
B: Clave® type of bung and syringe

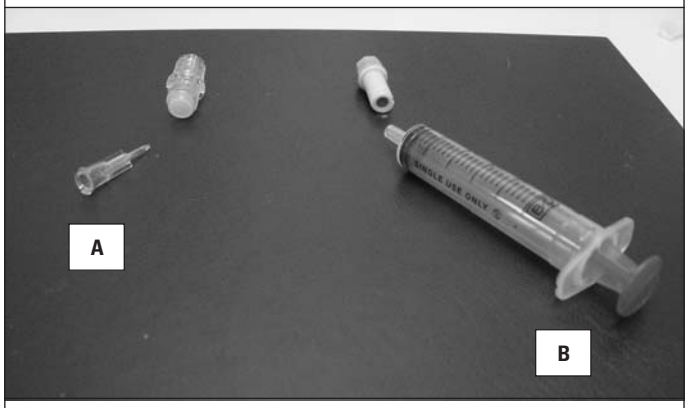
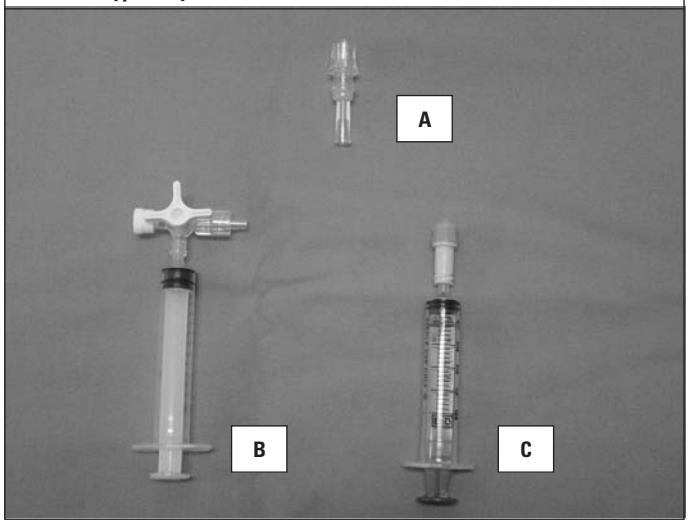


Figure 5b: Assembled systems:
A: interlink
B: 3-way stopcock
C: Clave® type of system



In South Africa universal use of these administration sets is prohibited by cost.

A cost analysis done at a Provincial hospital in Gauteng is as follows:

a) Administration set Y site = R1.77
b) Three-way stopcock with 50cm extension = R2.56
c) Standard IV catheter 18G = R2.17

Available NIIS are approximately three times more expensive, and product acceptance and correct use also continue to be a problem.

A cheap interim solution to obviate the need for a needle for drug administration, would be a 50cm extension set with a three-way stopcock placed in line with a standard administration set.

Conclusion

From the above discussion the following conclusions can be drawn:

a) Education is essential. The incidence of NSIs appears to be decreasing (Table III).
b) It should be emphasised that needlestick injuries tend to be under-reported. Some centres estimate that HCWs fail to report up to 70% of needlestick injuries. Reasons cited are the occurrence of sterile, or clean NSI (39%), little or no perception of risk to the employee (26%), that the employee is too busy (9%), and dissatisfaction with follow-up procedures (8%).[21] Authorities may use these statistics to justify their reluctance to improve safety for the HCWs.
c) Although costs for completely needleless systems may appear prohibitive in the South African situation, litigation against employers may eventually outweigh these costs. Legislation that has been implemented in North America by the OSHA may also be introduced in South Africa, necessitating that employers are compelled to buy more expensive but safer disposables.
d) The ideal situation would be to have available, in order of effectiveness: ESIPDs, at-hand disposable bins, three-way stopcocks or NIIS, plastic ampoules and blunt drawing-up needles.

Table III: Incidence of needlestick injuries per year at Pretoria Academic Hospital

Year	*Total number of NSIs*
1997	210
1998	241
1999	225
2000	253
2001	186
2002	162
2003	181

The final responsibility will always lie with the individual anaesthetist. It is of critical importance that every NSI is reported, and anaesthetists must insist on having safer fluid- and drug delivery systems in theatre.

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References

1. *Section 43 of the Occupational Health and Safety Act, 1993 (Act No 85 0f 1993) after consultation with the Advisory Council for Occupational Health and Safety promulgated the Regulations for Hazardous Biological Agents. Government Gazette no. 7233, no R 1390 of 27 December, 2001.*
2. *Risks, Incidence and Costs of Needlestick Injury. Medical Chronical. February 2004: 15-16.*
3. *Pugliese G. Evaluating sharps safety devices: meeting OSHA's intent. Infect Control Hosp Epidemiol. 2001; 22: 456-458.*
4. *MacPherson J. The interlink needleless intravenous system did not reduce the number of needlestick injuries in Christchurch hospital operating theatres. N Z Med J 1996; 109: 387-388.*
5. *Orenstein R, Reynolds L, Karabaic M, Lamb A, Markowitz SM, Wong ES. Do protective devices prevent needlestick injuries among health care workers? Am J Infect Control. 1995; 23: 344-351.*
6. *Ho AM, Ling E. Contamination susceptibility of three needleless and one standard needle injection systems. Can J Anaesth 1999; 46: 290-293.*
7. *Pugliese G, Germanson TP, Bartley J, Luca J, Lamerato L, Cox J et al. Evaluating sharps safety devices: meeting OSHA's intent. Occupational Safety and Health Administration. Infect Control Hosp Epidemiol 2001; 22: 456-8.*
8. *Mendelson MH, Short LJ, Schechter CB, Meyer BR, Rodriguez M, Cohen S et al. Study of a needleless intermittent intravenous-access system for peripheral infusions: analysis of staff, patient, and institutional outcomes. Infect Control Hosp Epidemiol 1998; 19: 401-406.*
9. *Seymour VM, Dhallu TS, Moss HA, Tebbs SE, Elliot TS. A prospective clinical study to investigate the microbial contamination of a needleless connector. J Hosp Infect 2000; 45: 165-168.*
10. *Brown JD, Moss HA, Elliot TS. The potential for catheter microbial contamination from a needleless connector. J Hosp Infect 1997; 36: 181-189.*
11. *Luebke MA, Arduino MJ, Duda DL, Dudar TE, McAllister SK, Bland LA et al. Comparison of the microbial barrier properties of a needleless and conventional needle-based intravenous access system. Am J Infect Control 1998; 26: 437-441.*
12. *Gartner K. Impact of a needleless intravenous system in a university hospital. J Healthc Mater Manage 1993; 11: 44-46, 48-49.*
13. *Yassi A, McGill ML, Khokhar JB. Efficacy and cost-effectiveness of a needleless intravenous access system. Am J Infect Control 1995; 23: 57-64.*
14. *Chew S, Mendoza M. Bacterial contamination of three-way taps-one Australian hospital's experience. Aust J Adv Nurs 1991; 8: 15-18.*
15. *Hatcher IB. Reducing sharps injuries among health care workers: a sharp container quality improvement project. Jt Comm J Qual Improv 2002; 28: 410-414.*
16. *Haiduven DJ, DeMaio TM, Stevens DA. A five-year study of needlestick injuries: significant reduction associated with communication, education, and convenient placement of sharps containers. Infect control Hosp Epidemiol 1992; 13: 265-271.*
17. *Ribner BS, Landry MN, Gholson GL, Linden LA. Impact of a rigid, puncture resistant container system upon needlestick injuries. Infect Control 1987; 8: 63-66.*
18. *Asai T, Hikada I, Kawashima A, Miki T, Inada K, Kawachi S. Efficacy of catheter needles with safeguard mechanisms. Anaesthesia. 2002; 57: 572-577.*
19. *Asai T, Matsumoto S, Matsumoto H, Yamamoto K, Shingu K. Prevention of needle-stick injury. Efficacy of a safe-guarded intravenous cannula. Anaesthesia 1999; 54: 258-261.*
20. *Kempen PM. Assessing blunt cannulae as replacements for hypodermic needles during intravenous therapy: safety and utility. Infect Control Hosp Epidemiol 1997; 18: 169-174.*
21. *Haiduven DJ, Simpkins SM, Phillips ES, Stevens DA. A survey of percutaneous/mucocutaneous injury in a public teaching hospital. J Hosp Infect 1999; 42: 83.*