HOSPITAL PROTOCOLS IN THE USE OF HEPARINIZED ARTERIAL PRESSURE LINES: A NATIONWIDE PRACTICE SURVEY

by

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ABSTRACT

A nationwide hospital practice survey was completed concerning heparin concentrations, base solutions, and methods of preparation of the arterial line flush systems. The purpose of this study was to ascertain common practices, thereby laying the groundwork for further research concerning the best ratio of heparin to solution to maintain arterial line patency. One hundred hospitals nationwide were surveyed by telephone. Ninety three percent of the participant hospitals use heparinized flush solutions, 69% used 2 units of heparin per 1 mL of base solution (2:1), 14% used 1 unit of heparin per 1 mL of base solution (1:1), 7% use a concentration greater than 2:1, and 1% use a concentration less than 1:1. Eighty seven percent use normal saline (NS) as the base solution and 9% use glucose and water (D5W). Methods of preparation varied as well. Fifty-five percent of the hospitals used commercially prepared 2:1 flush solution, 33% were prepared by Registered Nurses, 3% were prepared by pharmacy, and 2% by Respiratory Therapists. Further nursing research needs to be done concerning the most effective concentration of heparin to maintain arterial line patency.
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## Chapter 1

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INTRODUCTION TO THE PROBLEM

In the present climate of real and potential health-care reform, the nationwide trend of hospital restructuring and downsizing continues. This is being done in part as an attempt to contain the rising cost of health care. According to Evans (1993), by the year 2000, health care expenditures could reach 17% of the gross national product.

The cost of hospitalization represents 38% of all health care expenditures. As a result, nursing is increasingly challenged to find ways to decrease costs while maintaining or improving the quality of patient care. An excellent example of a research based change of traditional practice is the increasing use of normal saline (NS) as opposed to heparin flushes to maintain peripheral IV patency (Goode, 1991). Cost and patient safety were the primary impetus for many of the studies performed in the past decade comparing heparinized versus normal saline flushes. When studies supported the use of NS, patient safety improved, as the use of heparin can involve significant risk to the patient (Baldwin, 1989). Hospital costs were decreased dramatically, estimated from $10,000 to $66,402 per hospital annually, by reducing the amount of heparin used (Peterson, 1991).

A national research study comparing the use of NS
in arterial pressure lines to the traditional use of heparinized solutions was completed in 1992. The research protocol was developed by the American Association of Critical Care Nurses under the project title of "AACN Thunder Project®". The purpose of the project was to "evaluate the effects of heparinized and nonheparinized flush solutions on the patency of arterial pressure monitoring lines" (AACN, 1993). The results of this large scale, multi-center, randomized clinical trial supported the continued use of heparinized solutions in arterial pressure lines.

Heparinized arterial pressure monitoring lines were found to have a much greater probability of remaining patent than those with non-heparinized solutions (AACN, 1993). However, the advantage of increased patency rates must be balanced against the disadvantages of heparin use, including heparin-induced thrombocytopenia (HITP). Decreasing the amount of heparin received through arterial lines would be a consideration in patient safety, potentially decreasing the risks of side effects. Decreasing heparin use could also be a significant factor in reducing the cost of hospitalization. Not only the amount, but the method that heparin solutions are mixed can influence cost and patient safety. Different methods of preparation have varying costs. Premixed is the least expensive, as it
is purchased in bulk and does not require a pharmacist or nurse for on site preparation. The most expensive method is that prepared by the RN at the bedside, taking into account average RN salary and preparation time. Patient safety could be affected by the preparation method. Pre-mixed is potentially the most sterile. Pharmacist and RN preparation have a greater potential for medication error and contamination during preparation.

BACKGROUND AND SIGNIFICANCE

The concentrations of heparin to solution in pressurized systems vary from hospital to hospital, and are based on varying rationale. AACN confirmed this in 1990 with a national survey of its membership. Ninety-six percent of respondents reported using heparinized flush solutions in their arterial lines (Nationwide Practice, 1990). The remaining 4% used various nonheparinized solutions such as saline or glucose. The largest portion of members reported that their hospitals use 1:1 and 2:1 ratios of units of heparin to milliliters of solution. Thirty-four percent used a 1:1 ratio and 51% used 2:1. The remaining percentages reported using either lower or higher ratios (Nationwide Practice, 1990). There was no report on the amount of flush solution infused per hour. Fifty-
one percent of the respondents stated that their institution based policy on tradition, 17% on physician, manufacturer or pharmacy recommendations, and the rest didn’t know (Nationwide Practice, 1990).

Although not formally surveyed, anecdotal information reveals that there are varying methods of preparing the heparin solutions. Some institutions used pre-mixed heparin solutions, which is available in a 2:1 concentration (Baxter Laboratory, Abbott Laboratory, 1994). Those hospitals that use other than premixed heparin use varying methods of preparation. Some hospitals use pharmacy and/or RN preparation.

Pre-mixed heparin is the safest and least expensive method of preparation. Pharmaceutical companies prepare these solutions under the most rigorously sterile conditions (Schoonover, 1994). Hospital pharmacy prepared heparin solutions are prepared in optimal settings under a strictly maintained, hooded environment and often in large quantities. This is the second best method related to cost and safety (Schoonover, 1994). Preparation on the nursing unit is done without environmental control, with an increased risk of incorrect admixture, and is the most expensive when considering the time it takes to prepare related to average R.N. salary.

The AACN survey did not include the specific
heparin concentrations used by each facility (Nationwide Survey, 1990). A more precise understanding of nationwide hospital practice related to type of solution, heparin concentration, and method of preparation of pressurized arterial lines would be an important first step in clinical research. The results of that research could assist the acute care Nurse Practitioner in helping to establish hospital protocols and nationwide standards for the lowest acceptable heparin dose, prepared in the safest, least expensive method.

LITERATURE REVIEW

Heparin is an anticoagulant that acts by accelerating the action of antithrombin III, an inhibitor of thrombin (Hirsch, 1992). Heparin also neutralizes the activated forms of coagulation Factors: II, IX, X, XI, and XII (Melmon, Morrelli, Hoffman, and Neirenberg, 1992), which may prevent or retard the deposition of fibrin in and around the catheter, yielding a more accurate reading of the intra-arterial blood pressure (Kulkarni, 1994). Heparin is a frequently administered medication and is used in the majority of arterial pressure line systems. Fortunately, adverse reactions to heparin are relatively rare and often quickly reversible (Baldwin,
The two most frequently reported complications of heparin therapy are bleeding, usually resulting from prolonged prothrombin time (Melmon et al, 1992), and thrombocytopenia. Heparin can cause two types of thrombocytopenia. A mild form is associated with a transient fall in the platelet count, below 100,000/mm$^3$. Approximately 25% of patients receiving heparin develop mild, transient thrombocytopenia (Melmon et al, 1992). Some literature suggests that heparin induced thrombocytopenia may accompany the use of bovine lung heparin more than porcine heparin (Ansell, Price, Shah, and Beckner, 1985). The severe, delayed type of thrombocytopenia usually occurs 6-12 days after the start of heparin therapy (Carter, 1991). This type of thrombocytopenia is believed to be a consequence of an immune mechanism. The hemorrhagic and thromboembolic events associated with this type of thrombocytopenia are associated with a high incidence of mortality and morbidity (Baldwin, 1989). There may be an increased hospital stay of up to 50 days (Noormohamed et al, 1988). It has been estimated that 1% to 7% of the population receiving heparin will experience a thromboembolic event, (AACN, 1993).

Thromboembolic events related heparin induced thrombocytopenia have been implicated in heparin doses
consistent with the amounts used in flush systems alone (AACN, 1993). Asimacopoulou, Athanasiadis, McCarthy, Shade, and Teague (1994) suggest the possibility that heparin induced immune mediated injury to the pulmonary vasculature may be a cause of Adult Respiratory Distress Syndrome. High doses of heparin, administered for longer than 5 months, have been associated with osteoporosis and bone fractures (Carter, 1991).

Several recent studies have been published comparing normal saline (NS) to heparin in the maintenance of arterial catheter patency (AACN, 1993). Clifton et al, concluded that NS as a continuous flush was associated with an increased frequency of catheter occlusion (1991). The study was stopped at 30 patients due to detection of a statistically significance difference in patency rates. "Use of flush solutions containing heparin resulted in catheter survival rates of 100% and 86% at 40 and 96 hours respectively", (page 117). Catheters flushed with normal saline were found to have a lower survival rate, 52% after 40 and 96 hours (p<0.05). It is interesting to note that there were no catheter occlusions in any of the patients receiving low dose aspirin or subcutaneous heparin regardless of flush solution used (Clifton et al, 1991).

The AACN Thunder Project® (AACN, 1993) found
statistically significant differences in patency rates favoring heparinized solutions. A total of 5139 participants from 198 sites were studied. Patients were randomly assigned to a heparinized or nonheparinized flush group. Data were collected at 4-hour intervals for a total of 72 hours. Square waveform and arterial backflow tests were used to assess patency. Arterial pressure monitoring lines were found to have a 97% chance of remaining patent at 24 hours and 90% at 72 hours, if heparinized. If a nonheparinized solution was used, the patency rate was 93% at 24 hours and dropped to 79% at 72 hours. Four other variables were found to have a positive influence on the probability of patency: the patient was receiving anticoagulants or thrombolytics, the catheter was longer than 2 inches, a femoral insertion site was utilized, and the patient was male (AACN, 1993).

Kulkarni et al (1994), supported the findings of the AACN study, by showing that heparin worked better than NS in maintaining radial artery patency and function. Although the heparinized group had a slightly higher patency rate, the numbers were not statistically significant for the sample size (n=78). However, they did find significantly better accuracy of blood pressure readings within the heparinized group. Kulkarni et al (1994), recommended investigation of
optimum heparin concentrations.

Few studies comparing the effects of varying concentrations of heparin on patency rates have been reported. Bolgiano et al (1990) studied 104 intensive care unit patients comparing the dilution of 1 Unit of heparin/mL to .25 U/mL to the duration of patency. Two arterial lines out of the entire sample clotted off, one from each group (.25 U/mL and 1.0 U/mL). Therefore no difference between the groups was found, which lead to the conclusion that .25 U/mL is adequate to maintain patency. In 63 subjects, elective line removal occurred within 3 days. Forty-one subjects kept their lines for 3 to 5 days. As 61% of the lines were removed within 3 days, the findings of the study cannot be generalized to long-term arterial catheterization. An additional limitation of the study was reported by Bolgiano et al, "neither the exact amount of heparin flush solution used over the duration of this study nor the number of times the lines were flushed was controlled" (1990). However, the researchers believe that this had little impact, as the subjects were randomly assigned, and the coagulation values were not significantly altered.

An earlier study done by Butt, Shann, McDonnell, and Hudson (1987) contradicted Bolgiano's findings. They compared 1 U/mL to 5 U/mL in 470 pediatric
patients. This study concluded that the higher concentration of heparin produced significantly greater patency rates. However, there are limitations in generalizing this study to adult populations as Butt et al studied a pediatric population and used 22-gauge catheters as opposed to 20-gauge catheters utilized in most adult patients (Bolgiano, 1990).

SUMMARY
Recent studies have shown the benefit of heparinizing the flush solutions used in arterial pressure lines. However, heparin use is not without the possibility of side effects or risks. A nationwide hospital practice survey concerning heparin concentrations and solutions in use, as well as the method of preparations is warranted. Subsequent research could establish the lowest amount of heparin needed, prepared in the least expensive method.

DESIGN
A telephone survey was used for this study to ensure speed and increased accuracy of results. One hundred hospitals nationwide were sampled. One hundred
hospitals were selected on a convenience basis from the 198 sites used in the AACN Thunder® project. The AACN Thunder® list was chosen for expediency, as all hospitals on the list are known to use arterial lines. If there was difficulty in making contact, such as a wrong number, or unwillingness of the hospital to participate, an alternate hospital was contacted. The selected hospitals were offered the opportunity to participate in the survey. The researcher requested to be connected to one of the Intensive Care Units in the hospital. The researcher then asked to speak to the Nurse Manager, Clinical Nurse Specialist, Assistant Nurse Manager or Charge Nurse available. Willingness to answer the questions, and self-report knowledge of their hospital’s policy regarding arterial pressure monitoring was assessed. The respondents were informed of the content and purpose of the survey. The respondents were then questioned concerning their hospital’s policy for use of heparin to maintain arterial catheter patency (Appendix).

Upon completion of the data collection, the information was organized by type of pressurized solution (NS, D5W, etc.), if heparin was used, what concentration of heparin, how the heparin solution was mixed (pre-mixed, pharmacy, RN), and a description of the demographic data. Frequencies and percentages were
calculated on the data.

RESULTS

WHO WAS SURVEYED

The majority of hospitals surveyed were either community or university-affiliated hospitals. Ninety percent were not-for-profit institutions and hospital size was relatively even in distribution. Nearly 50% of the hospital units surveyed were combination adult intensive care units (see Tables 1, 2 and 3 for demographic details).

Table #1

<table>
<thead>
<tr>
<th>HOSPITAL CATEGORIES</th>
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<tbody>
<tr>
<td>COMMUNITY HOSPITALS</td>
<td>59%</td>
</tr>
<tr>
<td>UNIVERSITY-AFFILIATED HOSPITALS</td>
<td>26%</td>
</tr>
<tr>
<td>FEDERAL AND COUNTY HOSPITALS</td>
<td>15%</td>
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<tr>
<td>FOR PROFIT</td>
<td>10%</td>
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<tr>
<td>NOT-FOR-PROFIT</td>
<td>90%</td>
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<tr>
<td>HOSPITAL SIZE</td>
<td></td>
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<tr>
<td>-------------------------</td>
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<tr>
<td>LESS THAN 300 BEDS</td>
<td>32%</td>
</tr>
<tr>
<td>301-500 BEDS</td>
<td>36%</td>
</tr>
<tr>
<td>GREATER THAN 500 BEDS</td>
<td>32%</td>
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Table #3

<table>
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<th>TYPE OF ICU</th>
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<td>Neonatal ICU</td>
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<tr>
<td>Neuro Surgical ICU</td>
<td>1%</td>
</tr>
<tr>
<td>Cardiac ICU</td>
<td>14%</td>
</tr>
<tr>
<td>Surgical ICU</td>
<td>14%</td>
</tr>
<tr>
<td>Medical ICU</td>
<td>19%</td>
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<tr>
<td>Combination Adult ICU</td>
<td>49%</td>
</tr>
<tr>
<td>Trauma Only</td>
<td>1%</td>
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</tbody>
</table>

SURVEY ANALYSIS

One hundred (100) hospitals were surveyed by telephone. The survey revealed that 93% of the participant hospitals used heparinized flush solutions in their arterial lines. Seven percent used normal saline only. Of the hospitals using heparinized flush solutions, 87% used normal saline as the base solution, 9% used glucose (D5W), 1% used .045 normal saline, and 2% used both normal saline and D5W.
Heparin concentrations varied somewhat among institutions. Sixty-nine percent used 2 units of heparin per 1 mL of base solution (2:1), 14% used a 1:1, 3% used 5:1, 3% used 4:1, 1% used 3:1 and 1% used ½:1.

The method of preparation varied as well. Fifty-five percent used two brands of commercially prepared solutions (available in 2:1 concentration only). Fifty-five of the 68 intensive care units (ICUs) that use a 2:1 concentration purchased premixed solutions. Registered Nurses prepared 33% of the heparin mixtures, and the Pharmacy Department prepared 3% of the solutions. Two percent of the hospitals used Respiratory Therapists to prepare and maintain the heparinized flush systems.

DISCUSSION AND IMPLICATIONS

This survey showed a variety of different concentrations of heparin in use. Eighty-three percent of ICUs use a 2:1 or 1:1 concentration. Most institutions use a base solution of normal saline (88%). The results of this survey provided evidence in support of the findings of the AACN Nationwide Practice Survey (1990). The majority of those using a 2:1 concentration purchased a premixed solution. This begs the question as to whether this is the concentration of choice, or the most readily available and inexpensive
product. The AACN Thunder Project® results showed that heparin does affect patency rates, but very few studies have been done comparing patency rates of different heparin concentrations. These studies have significant limitations and are not easily generalized. Although even small amounts of heparin have been implicated in HITP, it still behooves nursing to attempt to ascertain the lowest dose of heparin needed to statistically and clinically address catheter patency. A follow-up study should be done comparing different concentrations of heparin to solution. If nursing research can establish the optimal dose of heparin, this could have implications for cost and safety nationwide. The lowest dose, prepared in the safest and most inexpensive manner would benefit patients, RNs and hospitals. Heparin flush manufacturers should be encouraged to produce premixed based on research data, so that cost and safety might be improved.

LIMITATIONS

The limitations of this study include sample size, and the potential for inaccurate reporting of actual practice.

CONCLUSION

In the present climate of hospital redesign and cost cutting priorities, it becomes increasingly important for nursing to find ways to decrease
expenses, while maintaining or improving quality of patient care. This is no small task. Research based practice maintains and defends quality of patient care, while in some cases, revealing opportunities to conserve resources. When this occurs, everyone wins.
Appendix

QUESTIONNAIRE

1. What type of ICU are you reporting from:
   A. PICU □
   B. NICU □
   C. NSICU □
   D. CICU □
   E. SICU □
   F. BICU □
   G. MICU □
   H. Combinations ICU ______________________
   I. Other □ ________________________________

2. What is your hospital policy concerning the use of heparin to maintain arterial catheter patency?
   A. What base solution do you use:
      Normal saline □
      Dextrose 5% and water □
      Lactated Ringers □
      Other ______________________
   B. Do you use heparin in your solution? ___
      If yes, what concentration of heparin to solution? (?U/mL) ____/____

3. If you use heparin, what method do you use for preparation? If a combination of methods is used,
approximately what percentage of each method?

A. Premixed □
   If so, what brand?_________
B. Pharmacy preparations □
C. R.N. preparations □
D. Other __________________________

4. Is this a:
A. Community Hospital □
B. University-affiliated Hospital □
C. Federal □
D. County □
F. Military □
G. For profit □
H. Not-for-profit □

4. Hospital size:
A. <300 beds □
B. 301-500 beds □
C. >500 beds □
REFERENCES


Schoonover, Lori, PharmD., Washington State University Pharmacy Department. Personal communication. (September, 1994).