Variability in the clinical practice of maintaining the patency of peripheral intravenous catheters

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(Variabilidad en la práctica clínica del mantenimiento de la permeabilidad de los catéteres venosos periféricos)

Abstract

Objective: To establish variations in clinical practice associated with maintaining the patency of peripheral intravenous catheters (PIC) and to determine to what extent such clinical practice falls within the limits of the available scientific evidence, based on a random sample of Spanish public hospitals.

Methods: A cross-sectional, descriptive study was carried out in non-psychiatric public hospitals and their associated medical and surgical units. Cluster (hospitals), stratified (hospital size), and single-stage (all units) sampling was applied. A questionnaire was mailed to all of the units involved.

Results: A sample of 341 valid questionnaires was analysed (response rate 54.5%). Only one praxis-modality was carried out in the majority of units. Intermittent flushing and heparin saline *versus* normal saline was the most frequent modality employed, over those of continuous flushing and non-heparinised saline. There was a high degree of variation in the quantity of heparin administered: 81.7% when flushing was carried out with heparinised saline and 48.2% when it was conducted with concentrated heparin. About 40% of this variation was associated with the hospital in question, rather than with the unit. The clinical practice fell within the limits of available scientific evidence in fewer than half of the units studied.

Conclusions: There was a high degree of variability in the practice of maintaining PIC patency. A significant part of this variation was attributable to the hospital in which the practice was carried out. Moreover, most of this practice was carried out beyond the limits of available scientific evidence.

Key words: Variation in clinical practice. Evidence-based nursing practice. Peripheral intravenous catheters. Heparin. Nursing practice.

Resumen

Objetivo: Determinar la variabilidad de la práctica clínica en el mantenimiento de la permeabilidad de los catéteres venosos periféricos en una muestra aleatoria de hospitales españoles y determinar en qué medida esta práctica se realiza dentro del rango de la evidencia disponible.

Métodos: Estudio descriptivo y transversal.

Ámbito y población: Hospitales públicos no psiquiátricos del Sistema Nacional de Salud y sus unidades médicas o quirúrgicas. Se realizó un muestreo por conglomerados (hospitales) estratificado (tamaño de los hospitales) y monoetápico (todas las unidades). Las variables se recogieron mediante un cuestionario administrado por correo postal.

Resultados: Se recibieron 341 cuestionarios válidos (tasa de participación del 54,5%). En la mayoría de las unidades sólo se realiza una modalidad de la práctica. El lavado intermitente frente al lavado continuo y el suero salino con heparina frente al no heparinizado son las modalidades más frecuentes. Hay una elevada variabilidad en la cantidad de heparina administrada: el coeficiente de variación intercuartílico es del 81,7% si el suero es heparinizado y del 48,2% si es con una dilución de heparina dada. Alrededor del 40% de esta variabilidad es atribuible al hospital y no a la unidad. En menos de la mitad de las unidades la práctica se realiza de acuerdo con la evidencia actual.

Conclusiones: Hay una gran variabilidad en la práctica del mantenimiento de la permeabilidad de los catéteres venosos periféricos. Una parte sustancial de esa variabilidad es incompatible con la evidencia actual, y una parte significativa de la variabilidad reside en el hospital donde se realiza la práctica.

Palabras clave: Variabilidad de la práctica clínica. Práctica de enfermería basada en la evidencia. Catéteres venosos periféricos. Heparina. Práctica de enfermería.

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Introduction

Maintaining the patency of peripheral intravenous catheters (PIC) is a common clinical practice in patients requiring medication and the administration of fluids and/or blood derivatives. Nevertheless, there are no universal directives governing the most appropriate form in which to implement it[1]. Two important considerations when looking at ways of regulating such practice are, on the one hand, to ensure that the catheter is continuously or intermittently flushed, and on the other, to make sure that the solution used is saline or heparin saline. The latter aspect is perhaps the most controversial, and is the one that has given rise to most research. Three meta-analyses have been carried out in this area; two in 1991[2,3] and a systematic review in 1998[4]. The first two meta-analyses concluded that intermittent flushing with the heparinised solution and with the saline solution were comparable in terms of permeability, catheter duration and the incidence of phlebitis. Moreover, on the basis of cost and in order to avoid the risks associated with the use of heparin (thrombocytopenia, haemorrhage, etc.), saline solution was regarded as the most recommendable option. Randolph et al.[4] confirmed these results when applying heparin in quantities of 10 International Units (IU), but also observed an increased incidence of phlebitis with this solution; on the other hand, when the dose of heparin applied was 100 IU, its application still proved advantageous, but the results obtained were less conclusive than in the previous case. Finally, in the case of continuous flushing, continuous perfusion of 1 IU/ml produced better results[4] than continuous perfusion of saline solution alone.

Moving from the field of efficacy to the field of effectiveness, one might ask how the patency of PIC is maintained in common practice and how congruent this common practice is with currently available evidence. With the exception of a small quantity of aggregate data spread over time and place[5-7], no studies have yet been carried out to examine the variability of this practice or to determine how it conforms to the available evidence. The main objective of this study was to describe variability in clinical practice related with maintaining PIC, in a random sample of Spanish hospitals. Their medical and surgical units were the data collection and analysis units. The conceptual framework of this investigation was quite broadly situated within the field of studying variations in medical practice. These studies have showed that an important part of the observed variability could be attributed to a certain degree of uncertainty with respect to what might constitute the most suitable procedure[8-12]. Along these lines, a second objective was to determine to what extent the practice of maintaining PIC was carried out within the limits of currently available scientific evidence.

Methods

Study design and area

A descriptive and cross-sectional study was carried out. The study setting consisted of non-psychiatric public hospitals belonging to Spain's National Health System[13]. The population comprised medical and/or surgical units (services) for adults, and other units which attend to patients with PIC, such as obstetric-gynaecological units, though it excluded those in which the frequency and length of use of peripheral channels was extremely limited or null, such as in psychiatric units, intensive care, etc.

The calculation of the sample size was based on a population of 205 non-psychiatric public hospitals[13] (with the 6 from the pilot study being subsequently excluded), with an estimation of 10 eligible units per hospital, based on the results of the pilot study. The total estimated population therefore consisted of 2,050 units. For a sampling error of 0.05, a confidence level of 95% and an assumed maximum variance ($p = q$) the necessary sample size was 353 units. Allowing for a non-response of 40%, the definitive sampling size rose to 600 units.

Cluster, stratified and single-stage random sampling was carried out. Although the data collection unit was the service or unit, the sampling unit chosen was the hospital. This was because a sampling framework was available at the hospital level, but not at the level of the units housed within it. Two strata were distinguished according to the number of beds: «big hospitals» ($\geq$ 882 beds) and «small hospitals» (< 882 beds). The cutt off mark was determined statistically (there is no common classifier for the whole of Spain) by means of an exploratory data analysis[14] which identified two homogeneous subpopulations at this point: 175 «small» hospitals and 24 «big» ones. 63 small hospitals and 8 big ones, making a total of 71 hospitals, were selected at random within each of the two strata by means of a table of randomly generated numbers. The resulting total number of eligible units housed in these hospitals was 626; 26 units more than the estimated sample (note that the hospitals were selected first and the number of units and their eligibility was determined afterwards).

Variables and instrumentation

The variables were gathered using a questionnaire that was specifically elaborated for this investigation. This questionnaire was completed by the matrons of the medical-surgical units in question. The questionnaire was pilot-tested on two occasions. The first test was presented to 10 matrons in order to evaluate its interpretability. The second test was used to evaluate all aspects,

including the data gathering process, and was sent to a sample of 119 matrons in the Community of Valencia. The questionnaire consisted of 33 questions, 26 of which had a closed format and 7 of which were open, and was divided into three sections: continuous flushing, intermittent flushing and characteristics of the units and hospitals. To determine which study units fell within the bounds of the existing evidence, three researchers independently drew conclusions that were relevant to the practice investigated by the three meta-analyses[2-4]. There was agreement on considering intermittent flushing with saline solution and continuous perfusion of saline heparinised with a concentration of 1 IU/ml of heparin as modalities that fell within the limits of the evidence. A third conclusion, relating to intermittent flushing with 100 IU of heparin, was considered too provisional by one of the three researchers. It was therefore decided to create two variables: «type I evidence» and «type II evidence». The first combined the two most solid implications, while the second incorporated the third, more provisional, implication[4].

Procedure

The questionnaire was delivered by post between May and June 2002. A pilot study had been previously carried out involving a sample of 119 medical-surgical units in six hospitals in the Community of Valencia. The procedure followed was based on the findings of the pilot study and on recommendations contained in the literature[15'16]. In order to ensure a good response rate, the questionnaire was sent three times in the space of three weeks.

Data analysis

A descriptive analysis of the categorical and continuous variables of this study was carried out. This focused on: frequency distribution, proportions and 95% confidence intervals (95% CI) for the categorical variables, and the mean, median, maximum and minimum and 95% CI for the continuous variables. The coefficient of variation (CV) and the coefficient of quartile variation (CQV) were used to measure variability, with the latter being considered the more robust measurement[17]. The ANOVA of random effects was used to separate the variance in the amount of heparin administered (expressed in IU) attributable to the variation among hospitals from the variation between units. Eta^2 was chosen as a measure of effect size and in our study it is the amount of variance attributable to the variability between hospitals. This analytical strategy is recommended as a screening technique to discover whether the data have a multilevel structure: if the value of Eta^2 is greater than 20 then there the data have a multilevel structure. The reply variables were transformed to homogenise the variances following the sequence of steps proposed by Hoaglin et al[18].

Results

341 valid questionnaires were received out of the 626 sent, making the global response rate 54.5%. The sample was comparable to the population in the two variables examined: administrative dependence (Insalud *versus* non-Insalud, and for the small hospital stratum, again on the basis of Autonomous Community) and the number of beds, both globally and within the two strata. The average number of patients per unit was 32 ± 12.2, and the average number of patients with PIC was 20 ± 10.7. In 94% of the units the practice(s) was/were carried out by the majority of the professionals employed by the unit(s) in question. The description of the participating units is summarised in table 1.

Variability in the practice of maintaining PIC amongst the units surveyed

Intermittent flushing as opposed to continuous flushing, and saline with heparin as opposed to non-heparinised saline were the main ways of implementing the practice of maintaining PIC (table 2). In most of the units only one modality was applied, although in about 25% of units more than one was carried out.

Continuous flushing was carried out in 32 units (9.4%), application without heparin in 30, and application with heparin in only 5 (note that there were more practices than units), the average IU/ml of heparin administered was 9.40 ± 4.67. The most commonly applied serum was saline, normally with a steady volume of 500 ml/day.

Intermittent flushing was carried out in 303 units (88.9%). In 134 (39.3%) only saline solution was used, while in 234 (68.6%) flushing was performed with saline solution and heparin. The former (flushing with saline solution alone) was often implemented after applying medication, after performing an extraction, or in both cases. On each occasion the average saline solution administered was 5.02 ± 3.13 ml, 95% CI (4.47 – 5.56). In the latter case (saline solution with heparin), flushing was carried out with heparinised saline (IFHS) in 151 units (44.3%) and with a specific dilution of heparin (IFdH) in 83 (24.3%) units.

In the case of IFHS, the main serum used was saline solution with 1% heparin, and the diluted solution

Table 1. Unit characteristics

	n	%
Type of unit		
Medical	168	51.1
Surgical	88	26.7
Mixed	51	15.5
Obstet-Gynaecological	22	6.7
Protocol		
Existence		
Yes	188	62.3
No	86	28.5
Don't know	28	9.3
Implementation date		
1980-1995	32	18.1
1996-1999	48	27.1
2000-2002	41	23.2
Don't know	56	31.6
Review date		
Has not been reviewed	32	18.1
Before 2000	48	27.1
2000	41	23.2
2001	56	31.6
Unknown	36	21.1
Degree of fulfilment		
Always or nearly always	150	82.0
Often (more than 1/2 the time)	25	13.7
Sometimes (less than 1/2 the time)	8	4.3
Authorship		
My unit's nursing team	38	20.8
Pharmacy service	6	3.3
Preventive medicine service	12	6.6
Mixed commission[a]	83	45.4
Others[a]	44	24.0

[a]In most cases, composed by nurses.

had an average concentration of 78.54 ± 107.72 IU/ml of heparin (Mdn = 47.62). This kind of flushing was normally carried out after applying medication or performing an extraction. On each occasion the average IU of the heparin administered was 290.79 (Mdn = 58.82), and the CQV was 81.7% (table 3).

IFdH was carried out in 83 units (24.3%), in three-quarters of which a commercial preparation, Fibrilín®, was used, while in the rest a 1% dilution of heparin was employed. The average IU of heparin administered was 381.9 (Mdn = 60) and the CQV was 48.2. There were considerable differences with respect to the amount of heparin administered in these two submodalities. The minimum value of units administered involving the 1% heparin solution (500 IU) were much greater than the maximum value of units administered associated with the other modality (200 IU) (table 3). More than half of the nursing units that performed these two submodalities did so after applying medication or carrying out an extraction.

Variability in practice among hospitals

The practice of maintaining PIC was carried out in 4 or 5 different ways in 11.8% of the hospitals, while in 35.3%, 19.6% and 33.3% of hospitals, it was carried out in three, two and one way(s), respectively. The variability in the average IU of heparin administered per hospital (in hospitals with four or more medical and surgical units) is shown in tables 4 and 5. In IFHS (table 4), the CQV was 71.1, ranging from 0 to 94.19. In IFdH (table 5), the CQV between hospitals was 84.7, ranging from 0 to 97.4; in this case two hospital subgroups were observed, one with high variability, and the other with low variability.

ANOVA data for random effects show that a significant part of the variability relating to the units of heparin administered, in the two modalities, was attributable to variability among hospitals, 43% and 37% respectively; in other words, it did not depend on the medical-surgical units themselves but rather on the hospital under which these units were grouped. These eta^2 coefficient values also indicated the existence of a hierarchical structure in the data, which made it impossible to estimate an unbiased predictive model, unless it was a multilevel model[19].

Table 2. Type of practice for maintaining peripheral intravenous catheters

Type of practice	n	%[a]	95% CI
Continuous flushing	32	9.4	6.3-12.5
Continuous flushing without heparin	30	8.8	5.8-11.8
Continuous flushing with heparin	5	1.5	0.2-2.8
Intermittent flushing	303	88.9	85.5-92.3
Intermittent flushing without heparin	134	39.3	34.1-44.5
Intermittent flushing with heparinised saline	151	44.3	39.0-49.6
Intermittent flushing with a given dilution of heparin	83	24.3	19.8-28.9
Does not comply with any of the above	31	9.0	7.4-10.5

[a]The percentages are based on the total sample (n = 341), and their sum is greater than 100% because in one unit there may be more than one practice.

Table 3. Statistics for the heparin units involved in intermittent flushing

	$\bar{x}$ (SD)	95% CI	Median	Min	Max	CV (%)	CQV (%)
IFHS (n = 147)[a]	290.79 (107.72)	157.96-423.62	58.82	1	5,000	280.2	81.7
IFdH (n = 73)[a]	381.90 (769.60)	202.35-561.46	60.00	10	3,000	201.5	48.2
Heparin 1% (n = 14)	1,767.86 (846.17)	1,279.3-2256.4	1625	500	3,000	47.86	–
Fibrilin® (n = 59)	52.03 (30.09)	44.34-60.03	60.00	10	200	57.66	–

IFHS: intermittent flushing with heparinised saline; IFdH: intermittent flushing with a given disolution of heparine. CV: intrahospital coefficient of variation; CQV: intrahospital quartile coefficient of variation; $\bar{x}$: mean; SD: standard derivation; 95% CI: 95% confidence interval; Min: minimum value; Max: maximum value.

Table 4. Heparin units per hospital, in hospitals with 4 or more medical-surgical units, and the variation coefficient of intermittent flushing with heparinised saline

Hospital	$\bar{x}$ (DS)	Median	Q_3-Q_1	CV (%)	CQV (%)
123 (n = 4)	50.00 (0.00)	50.00	0.00	0.00	0.00
26 (n = 4)	4,886.36 (227.27)	5,000.0	340.91	4.65	3.53
157 (n = 5)	23.86 (9.83)	22.43	18.87	41.20	38.97
60 (n = 4)	370.45 (157.17)	400.00	288.64	42.43	40.58
40 (n = 7)	74.97 (83.44)	24.88	78.24	111.30	66.39
83 (n = 4)	196.32 (233.01)	83.76	360.61	118.69	71.38
19 (n = 8)	57.41 (44.49)	58.83	84.16	77.50	73.91
46 (n = 11)	114.18 (139.38)	100.00	123.06	122.07	75.65
120 (n = 4)	27.32 (23.06)	27.38	42.08	84.41	77.12
59 (n = 4)	919.64 (809.60)	791.67	1,532.74	88.03	77.91
12 (n = 7)	191.12 (362.75)	29.7	180.39	189.80	82.14
98 (n = 4)	66.51 (61.61)	59.90	114.90	92.63	82.28
29 (n = 5)	346.50 (409.24)	98.04	682.77	118.11	83.55
28 (n = 4)	288.20 (354.06)	161.70	621.47	122.85	88.42
37 (n = 5)	157.77 (284.70)	37.13	336.26	180.45	89.46
21 (n = 5)	18.21 (16.94)	18.80	33.14	93.03	92.99
78 (n = 4)	179.05 (224.35)	108.02	404.19	125.30	94.19
CV (%)	247.27				
CQV (%)	71.13				

CV: intrahospital coefficient of variation; CQV: intrahospital quartile coefficient of variation; Q_3-Q_1: quartile range; n: number of medical or surgical units; $\bar{x}$: mean; SD: standard derivation.

Table 5. Heparin units per hospital, in hospitals with 4 or more medical-surgical units, and the coefficient of variation in intermittent flushing with a given dilution of heparin

Hospital	$\bar{x}$ (SD)	Median	Q_3-Q_1	CV (%)	CQV (%)
28 (n = 6)	60.00 (0.00)	60	0.00	0.00	0.00
53 (n = 5)	20.80 (1.79)	20	2.00	8.61	4.8
60 (n = 4)	65.00 (10.00)	60	15.00	15.38	11.1
42 (n = 4)	58.75 (14.36)	60	26.25	24.44	22.8
41 (n = 4)	32.50 (15.00)	40	22.50	46.15	39.5
1 (n = 6)	495.00 (982.89)	100	66.75	198.56	82.7
29 (n = 6)	396.67 (788.02)	60	620.00	198.66	91.2
12 (n = 11)	663.64 (983.41)	60	1,480.00	148.18	97.4
CV (%)	113.7				
CQV (%)	84.7				

CV: intrahospital coefficient of variation; CQV: interhospital quartile coefficient of variation; Q_3-Q_1: quartile range; n: number of medical or surgical units; $\bar{x}$: mean; SD: standard derivation.

The practice of maintaining PIC and how this conforms to the evidence

According to the first definition of evidence (type I), the practice was followed within the range of evidence in only 3 out of every 10 units (31.9%). According to the second, and wider-ranging, definition (type II), the practice was followed within the range of evidence in 4 out of every 10 units (41.9%).

Discussion

Intermittent flushing, as opposed to continuous flushing, is the prevalent method for maintaining PIC in the case of the medical and surgical units of public hospitals in Spain. Within intermittent flushing, the use of heparinised saline is the most common practice though flushing with saline solution is also frequent. If flushing is continuous it is unusual for it to be carried out with heparinised saline.

The variability in the quantity of international units of heparin administered on each occasion is high: it is greatest when the heparin is diluted in a saline solution and least when a dilution of heparin is directly administered. In this latter case two submodalities can be distinguished: the use of a commercial preparation (Fibrilin®) or of a 1% dilution of heparin (less common). In both cases the variation coefficients were high, but the most notable aspect was that there were considerable differences in the quantity of IUs of heparin administered. There was a clearly observable floor effect, as no less than 500 IU were administered in the case of the 1% dilution. It could therefore be seen that the amount of heparin administered depended on the method of administration.

The data clustered at the hospital level showed great variability among hospitals; accounting for almost half of all the variability observed. In statistical terms, this signified the presence of a hierarchical structure in the data. This has two implications: *a)* the performance of the practice of maintaining PIC depends –to a substantial degree– on the hospital in which it is carried out, and partly on the unit involved (the part directly attributable to professional staff is probably very small according to the intraunit homogeneity indicators), and *b)* in accordance with this, any unbiased examination of the causes of this variability calls for the application of a multilevel design. In Spanish hospitals intermittent flushing with heparinised saline is almost twice as common as it is with saline solution. This stands in contrast to the situation in Australian hospitals (the only current comparison available in the literature), where flushing with saline solution is the norm[7].

With regard to the most basic –intraunit– level of analysis, which was not a direct object of this study, a certain amount of somewhat contradictory data was obtained. On the one hand, our findings suggest a high degree of uniformity in the practices implemented by professionals within the units, but on the other, there are indications to the contrary: in almost half of the units surveyed there were no established protocols, and in approximately a quarter of them several modalities were applied within the same practice.

Two definitions were established for evidence relating to this practice. One definition, type I evidence, incorporated two firm implications, whereas the other, type II evidence, included a third, and more provisional, implication. Only 31.9% of the units, according to the first of the definitions, and only 41.9%, according to the second, carried out practices that conformed to the evidence. Furthermore, it should be stressed that the fact that the findings coincide with the evidence, does not necessarily mean that they are based on the evidence. Literature relating to the diffusion and use of research, in general, and more specifically to its application in the area of nursing, shows the cultural and temporal distance between the production of findings (research context) and their implementation (practice context)[20]. It also shows that research literature does not feature among the main sources of information used by nursing professionals when making clinical decisions: their main sources for such guidance tend to be: doctors, colleagues, reference manuals, experience, etc.[21,22]. As far as nursing manuals published in Spanish during the last 10 years are concerned, no common guidelines have been set with respect to these practices, nor have references been made to suitably high level evidences or been kept up-to-date, for example[23,24].

With respect to the limitations of this study, we have used a mailed questionnaire to examine the variability of this practice among medical and surgical units with the collaboration of a key informant by unit; almost always the matron. The pilot study compared the convergence between mailed surveys and telephoned reports involving 20 informants and this was found to be maximal. Even so, the criterion validity of the informant's report was not established. Another potentially debatable aspect related to the delimitation of practices deemed to conform to the evidence: the question of the validity of these implications still remains to be resolved. In other words, it has yet to be firmly established whether the investigation provides sufficient evidence to enable the unequivocal establishment of relevant conclusions relating to this practice.

Two clear suggestions can be made for further studies. On the one hand, it seems necessary to establish –perhaps with the help of a panel of experts– a series of directives relating to the practice of maintaining PIC

and to disseminate them appropriately within the conceptual and empirical framework of the diffusion of innovations and the use of research[25,26]. On the other hand, it seems necessary to analyse, by means of a multilevel design, the factors that explain the variability observed amongst different medical and surgical units.

In conclusion, this study shows: *a)* that there is great variability in the application of the practices aimed at maintaining the patency of peripheral intravenous catheters; *b)* that a substantial portion of this variability is not compatible with the current evidence, and *c)* that a significant part of the variability resides in the hospital where the practice is carried out. These findings are compatible with the most solid hypotheses relating to variability in practice[27,9] and the use of research[28,29]. It is apparent that a lack of clear evidence and a lack of existing knowledge on the part of professionals cause variability, and that the use of research findings and different types of practice are largely determined by supraindividual variables; in this particular case by the unit and the hospital.

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