



# Development and clinical application of nursing-sensitive indicators for midline catheterization care using evidence-based methods

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**Background:** Midline catheters (MCs) have been widely applied in clinical settings as they can provide painless venous access, thus improving the quality of life and reducing medical costs. Nursing-sensitive indicators (NSIs) are real and effective measures of nursing quality. Using evidence-based methods, we established the NSIs of MC care, with an attempt to provide a basis for evaluating and monitoring nursing quality for MC use.

**Methods:** An electronic search was performed in 5 databases including China National Knowledge Infrastructure (CNKI), Chinese Scientific Journal Database (VIP), Wanfang Data, PubMed, and Web of Science to identify studies that evaluated nursing quality during MC use. Two evaluators independently selected literature, extracted data, and evaluated the risk of bias. According to the Donabedian's structure-process-outcome model, we divided the NSIs into 3 levels.

**Results:** The established NSIs for MC use included 3 indicators (i.e., structure indicators, process indicators, and outcome indicators), among which there were 3 level-2 indicators and 7 level-3 indicators at the structure level, 2 level-2 indicators and 9 level-3 indicators at the process level, and 5 level-2 indicators and 17 level-3 indicators at the outcome level.

**Conclusions:** The established NSIs for MC use offer a set of objective criteria for evaluating nursing performance during MC use and will help to improve nursing quality control.

**Keywords:** Nursing quality; sensitive indicators; evidence-based medicine; midline catheter (MC)

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## Introduction

Midline catheters (MCs), typically 8–25 cm in length, can provide venous access. MCs have been widely applied in clinical settings as they can prevent patients from suffering pain induced by repeated puncture and lower medical costs by sparing the use of X-ray positioning (1,2).

While nursing quality evaluation is an essential component of hospital management, nursing-sensitive indicators (NSIs) are real and effective measures of nursing quality (3,4). In 1998, the American Nurses Association (ANA) created the National Database for Nursing Quality Indicators (NDNQI), first proposing the concept of NSIs,

which quantitatively evaluate the quality of a variety of functions (e.g., nursing management and clinical practice) that specifically affect patient outcomes by assessing the processes and outcomes of nursing services. It can be used to guide nursing services by providing measurable evaluation criteria for nursing performance (5,6).

The nursing quality evaluation indicators are widely used across different clinical studies, and often related to other medical factors. Therefore, determining standard NSIs for MC use will be valuable for improving nursing performance. In our current study, by using evidence-based methods, we retrieved a large number of clinical studies on MC nursing, evaluated the quality of included studies, integrated and categorized the outcome indicators of NSIs in these studies, and tried to establish NSIs for MC use.

## Methods

### Literature screening

#### Inclusion criteria for selecting articles

The inclusion criteria for articles are listed below according to category.

- (I) Subjects: there was no limitation on the age, gender, or ethnicity of the study participants or on the disease/condition.
- (II) Interventions: MC care was involved.
- (III) Research types: various types of clinical studies including randomized controlled trials, non-randomized controlled trials, cohort studies, and case-control studies, published in English or Chinese language, were searched.
- (IV) Outcome indicators: MC-related outcome indicators included nursing before, during, and after catheterization; nursing of complications; nursing before, during, and after extubation; satisfaction; and adverse reactions.

#### Exclusion criteria for selecting articles

Articles were excluded for any of the following reasons: (I) full-text versions of the articles were not accessible via electronic retrieval or manual retrieval; (II) publications were overlapping; (III) key information such as interventions and outcome indicators could not be extracted; (IV) articles contained abnormal data, incomparable baseline data, and/or incomplete data; and (V) the literature was gray literature such as dissertations and papers presented at academic conferences or workshops.

### Literature search strategy

We performed a literature search for eligible studies published before July 26, 2020 from 5 databases including China National Knowledge Infrastructure (CNKI), Chinese Scientific Journal Database (VIP), Wanfang Data, PubMed, and Web of Science. The subject words, combined with free words, were used in the retrieval strategy. Both English and Chinese keywords were searched, including “MC”, “MVC”, “medial venous catheter or midline”, “midline catheters”, and “nursing”. References and related journals were manually searched to obtain clinical studies on MC nursing interventions. For instance, the specific search strategy in the Web of Science was as follows: TS = (MC OR MVC OR medial venous catheter or midline OR midline catheters) AND TS=nursing.

### Literature screening and data extraction

Two researchers independently completed literature screening. First, by reading the titles and abstracts, they ruled out articles that did not meet the inclusion requirements; articles that did not clearly meet the inclusion criteria during the preliminary screening were subjected to a full-text review and stratified into an included or excluded group. Any questions, disagreements, or inconsistencies would be discussed intensively or addressed by consultation with a third expert. Data extraction (including name of the first author, publication time, literature title, outcome indicators, and risk of bias) was conducted independently by the 2 researchers. The results were cross-checked by these 2 researchers; again, any issues that arose would be negotiated or addressed by consultation with a third researcher.

### Assessment of publication bias

The risk of bias was assessed by 2 independent researchers. Study quality was assessed according to the Jadad Score (7). In this system, a score of 1–3 indicates a low-quality study while a score of 4–7 indicates a high-quality one. The following criteria were used:

- (I) Randomization:
  - (i) Appropriate (2 points), if random sequence is generated by computational algorithms or simulation methods;
  - (ii) Unclear (1 point), if a trial does not provide its randomization method (1 point);
  - (iii) Inappropriate (0 point), if an alternate assignment method is used, such as the allocation of odd and even numbers.
- (II) Randomization concealment:

- (i) Appropriate (2 points), if any allocation method that clinicians and subjects cannot predict is used, including the distribution scheme is controlled by a center or pharmacy, containers with consistent serial numbers, on-site computer control, sealed opaque envelopes, etc.;
  - (ii) Unclear (1 point), if only a random number table or other random allocation scheme is applied;
  - (iii) Inappropriate (0 point), if any method with predictable assignments is used, including alternate allocation, case numbers, days of the week, an open-label random number table, serial-coded envelopes, etc.;
  - (iv) Absent (0 point), if randomization is not used.
- (III) Blinding method:
- (i) Appropriate (2 points), if the same placebo form or a similar method is used;
  - (ii) Unclear (1 point), if it is a blinded trial without any information of blinding methods;
  - (iii) Inappropriate (0 point), if an inappropriate blinding method is used, such as a comparison between tablets and injections.
- (IV) Withdrawal and exit:
- (i) The number and reasons of patients withdrawing or exiting are described (1 point);
  - (ii) Otherwise (0 point).

The methodological quality of observational studies (e.g., case-control studies, cohort studies, case series, and case reports) were assessed by using the use the Newcastle–Ottawa Scale (NOS) (8), which consists of 3 main aspects: the methods used for selecting cases and controls, the comparability between the case group and the control group, and the evaluation method of exposure. Eight evaluation items were used, and the results are indicated by stars. The quality evaluation was carried out independently and cross-checked by 2 researchers, and any disagreement was settled by negotiation or by consulting a third researcher.

### Construction of NSIs

In the 1960s, Donabedian proposed the structure–process–outcome model of quality, focusing on 3 aspects including structure quality management, process quality management, and result quality management (9). The NSIs were established and validated based on this theory. As of 2014, 18 NSIs have been selected by the NDNQI (10): (I) structure indicators including staffing mix, nursing

hours per patient day, satisfaction of registered nurses, and education level of registered nurses; (II) process indicators including physical constraints and pain evaluation–intervention–re-evaluation; and (III) outcome indicators including satisfaction, adverse reactions, stratified care, and compliance.

## Results

### Results of literature search

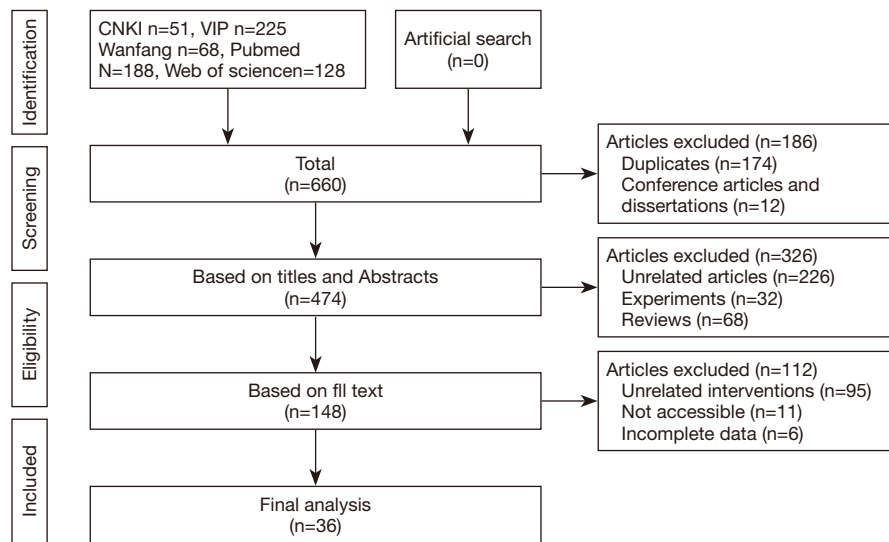
Out of the initial 460 articles obtained, 174 were duplicates and hence excluded from further analysis; 12 conference/workshop papers were excluded, and another 126 articles were excluded on the basis of title and abstract. From the articles that remained, 112 articles were excluded on the basis of their full-text, for reasons of incomplete data (n=95), unrelated interventions (n=95), and lack of access to the full text (n=11). Ultimately, 36 studies including 17 randomized controlled trials and 19 observational studies, comprising 3060 MC users, entered the final analysis (*Figure 1*).

### General description and quality evaluation of the included articles

All the 17 RCTs described the baseline data and declared that these data were comparable; however, none mentioned blinding or allocation concealment, and there was no withdrawal/exit data. Only 2 studies described the specific randomization method. The quality of each article was evaluated by using the Jadad score and NOS (*Table 1*).

### Establishment of NSIs for MC care

NSIs extracted from literature were divided into 3 levels according to the structure–process–outcome theory (*Table 2*). The NSIs for MC care in the enrolled articles were further analyzed, and the frequency distribution of the outcome was analyzed. Among the MC users, the rate of care for complications reached 100%, and the rate of nursing before catheterization reached 50%. During the proactive nursing, the complications associated with MC infusion and the estimated cost of the treatment were carefully explained to the patients and their families. Informed consent was obtained. The rate of nursing (mainly the aseptic techniques applied according to clinical standards) during catheterization reached 47.2%, and the rate of nursing (including timely dressing change, catheter cleansing,



**Figure 1** Literature search and screening flowchart.

**Table 1** Basic information of the enrolled studies

Studies included	Research type	n	Mode of nursing	Duration of indwelling (d)	Site of catheterization	Method of catheterization	Quality evaluation
Li 2020, (11)	RCT	100	–	–	A and B	–	2
Liu 2020, (12)	RCT	70	–	4–96	–	–	1
Wang 2020, (13)	RCT	60	–	–	–	–	2
Xu 2020, (14)	RCT	70	–	23.22±3.51	–	–	2
Yan 2020, (15)	RCT	120	–	22.30±1.47	A, B, and C	–	1
Yang 2020, (16)	RCT	50	–	–	–	–	1
Dong 2019, (17)	RCT	93	–	3–47	–	–	1
Gao 2019, (18)	RCT	60	Clinical nursing	–	–	–	1
Gu 2019, (19)	Observational study	56	–	10–50	–	1	a
He 2019, (20)	RCT	80	–	–	–	2	1
Jing 2019, (21)	Observational study	104	–	–	–	–	b
Li 2019, (22)	RCT	100	–	–	–	–	1
Sun 2019, (23)	RCT	124	–	31.8±2.4	–	–	1
Wang 2019, (24)	RCT	116	–	–	–	1	1
Yu 2019, (25)	Observational study	1	–	–	C	–	b
Zhang 2019, (26)	RCT	110	–	7–55	A, B, and C	–	2
Zhao 2019, (27)	Observational study	1	–	49	C	–	b
Hong 2018, (28)	RCT	200	–	17.97±9.55	C	–	1
Lin 2018, (29)	Observational study	12	–	22	C	1	2
Liu 2018, (30)	RCT	136	–	–	A	1	1
Yao 2018, (31)	RCT	306	–	–	A and C	–	1

**Table 1** (continued)

Table 1 (continued)

Studies included	Research type	n	Mode of nursing	Duration of indwelling (d)	Site of catheterization	Method of catheterization	Quality evaluation
Zhang 2018, (32)	RCT	252	Clustered	9±24.3	A and C		1
Wang 2017, (33)	Observational study	20	–	9.6	A, B, and C	I	1
Wang 2016, (34)	Observational study	185	–	3–30	A, B, and C		b
Wang 2016, (35)	Observational study	30	–	6–28	A, B, and C	II	b
Dong 2015, (36)	Observational study	56	–	–	–	–	b
Li 2015, (37)	Observational study	44	–	7–49	A, B, and C		b
Gao 2014, (38)	Observational study	62	–	–	–	–	a
Dong 2012, (39)	Observational study	128	–	8–49	–	–	b
Pang 2012, (40)	Observational study	118	–	–	–	–	b
He 2012, (41)	Observational study	30	–	–	A, B, and C	I	b
Dong 2011, (42)	Observational study	52	–	–	A, B, and C	I	b
Wang 2011, (43)	Observational study	40	–	30	A, B, and C	I	b
Yu 2011, (44)	Observational study	50	–	–	D	I	b
Li 2010, (45)	Observational study	12	–	–	A, B, and C	–	b
Zhou 2009, (46)	Observational study	12	–	7–39	A, B, and C	I	b

A = median cubital vein; B = cephalic vein; C = basilic vein; D = anterior cubital vein; I = Seldinger technique; II = ultrasound-guided Seldinger technique; a = 4 stars (according to NOS); b = 3 stars (according to NOS); 1 = 1 point (according to Jadad score). RCT, randomized controlled trial.

Table 2 Nursing-sensitive indicators (NSIs) for midline catheters (MCs) care

NSIs	n	Frequency
Nursing of complications	36	100.0%
Nursing before catheterization	18	50.0%
Nursing during catheterization	17	47.2%
Nursing after catheterization	17	47.2%
Patient satisfaction	11	30.6%
Mental health nursing	3	8.3%
Extubation nursing	2	5.6%
Average cost of infusion tools	2	5.6%
Patient's compliance	2	5.6%
Pain management nursing	2	5.6%
Health education	2	5.6%
Puncture success rate	2	5.6%
Quality of life	1	2.8%
Total number of puncture attempts	1	2.8%
Catheter maintenance compliance rate	1	2.8%
Wound healing time	1	2.8%

catheter sealing, and catheter care) after catheterization was also 47.2% (Table 3).

### Clinical application of NSIs for MC care

No clinical guideline or expert consensus on NSIs for MC care has been established. As seen in our analysis on the NSIs for MC care, the quality of NSIs for MC care varied, was highly heterogeneous across different studies, and the relevant indicators in the literature showed low standardization. Therefore, the methods of evidence-based medicine were employed in our current study to make the NSIs for MC care more standardized, uniform, and scientific, and thus better able to guide clinical practice.

## Discussion

### Strength of our current study

In China, research on NSIs is still in the exploratory stage, and NSIs for specific disciplines have not yet been established. Based on Donabedian's structure-process-outcome model and by employing the methods of evidence-

**Table 3** Frequencies of nursing-sensitive indicators (NSIs) for midline catheters (MCs) care

Level 1 indicators	Level 2 indicators	Level 3 indicators
Structure indicators	Bed-to-nurse structure	Bed-to-nurse ratio/patient-to-nurse ratio
	Staffing mix	Education degree of nurses Professional titles of nurses Age of nurses Length of service Scores of the theoretical knowledge and practical skills of the nurses
Process indicators	Monitoring of environmental hygiene and sanitation	Ward: whether the ambient temperature and humidity in the ward are compatible with the patients' conditions
	Physical constraints	Frequency of physical restraint for inpatients
		Rate of self-dependence assessment
		Accuracy of nutritional assessment
Pain assessment	Empathy of nurses	
	Maintaining the privacy and dignity of patients	
	Puncture success rate	
Outcome indicators	Satisfaction	Total number of puncture attempts
		Catheter maintenance compliance rate
	Adverse reactions	Pain assessment compliance rate
		Patient satisfaction
	Stratified care	Nurse satisfaction
		Blood or fluid released from the puncture site
		Infections
		Catheter occlusion
		Mechanical phlebitis
		Nursing before catheterization
Nursing during catheterization		
Nursing after catheterization		
Compliance	Mental health nursing	
	Pain management nursing	
Costs	Extubation nursing	
	Wound care	
	Daily life care	
		Patient's compliance
		Nurse's compliance
		Costs of midline catheter tools

based medicine, this study is the first to analyze NSIs for MC care and establish the NSIs for MC care at the structure, process, and outcome levels, with an attempt to enrich the concept of high-quality nursing and thus improve the quality of nursing services in clinical settings.

### *Limitations of our current study*

The analysis of the NSIs was based on literature review and data integration. Only Chinese-language articles were included in this analysis, and the overall methodological quality of these studies was unsatisfactory. Finally, the NSIs used in these articles had variable quality and were not standardized.

### *Prospects*

To make the NSIs for MC care more suitable for clinical needs and to improve our understanding of clinical care, we will further screen and optimize the relevant indicators by (I) establishing an NSI research group, (II) adopting the 3-round Delphi method, (III) convening expert consensus meetings, and (IV) carrying our large-scale, multicenter clinical research to validate the clinical value of the final NSIs. We hope the new NSIs for MC care will be further applied in clinical settings and thus offer objective evaluation standards for nursing services and the improvement of nursing quality.

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### **Footnote**

*Conflicts of Interest:* All authors have completed the ICMJE uniform disclosure form (available at <http://dx.doi.org/10.21037/apm-20-2466>). The authors have no conflicts of interest to declare.

*Ethical Statement:* The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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