

Impact of a Bedside Procedure Service on General Medicine Inpatients: A Firm-Based Trial

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BACKGROUND: Procedure services may improve the training of bedside procedures. However, little is known about how procedure services may affect the demand for and success of procedures performed on general medicine inpatients.

OBJECTIVE: Determine whether a procedure service affects the number and success of 4 bedside procedures (paracentesis, thoracentesis, lumbar puncture, and central venous catheterization) attempted on general medicine inpatients.

DESIGN: Prospective cohort study.

SETTING: Large public teaching hospital.

PATIENTS: Nineteen hundred and forty-one consecutive admissions to the general medicine service.

INTERVENTION: A bedside procedure service was offered to physicians from 1 of 3 firms for 4 weeks. This service then crossed over to physicians from the other 2 firms for another 4 weeks.

MEASUREMENTS: Data on all procedure attempts were collected daily from physicians. We examined whether the number of attempts and the proportion of successful attempts differed based on whether firms were offered the bedside procedure service.

RESULTS: The number of procedure attempts was 48% higher in firms offered the service (90 versus 61 per 1000 admissions; RR 1.48, 95% CI 1.06-2.10; $P = .030$). More than 85% of the observed increase was a result of procedures with therapeutic indications. There were no differences between firms in the proportions of successful attempts or major complications.

CONCLUSIONS: The availability of a procedure service may increase the overall demand for bedside procedures. Further studies should refine the indications for and anticipated benefits from these commonly performed invasive procedures.

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KEYWORDS: bedside procedures, health services needs and demands, technology (medical), teaching hospitals.

Inpatient bedside procedures are a major source of preventable adverse events in hospitals.^{1,2} Unfortunately, many future inpatient physicians may lack the training³ and confidence⁴ to correct this problem. One proposed model for improving the teaching, performance, and evaluation of bedside procedures is a procedure service that is staffed by faculty who are experts at inpatient procedures.⁵ In a recent survey of internal medicine residents from our hospital, 86% (30 of 35) believed that expert supervision would improve central venous catheterization technique (Trick WE, personal communication).

Primary considerations in the development of a procedure service are the baseline demand for bedside procedures and whether a procedure service may affect this demand. Though

variations in population-based rates of some hospital procedures have been described,^{6,7} there is little written on the demand for procedures performed at the bedsides of inpatients. Concomitant increases in demand and availability of other technologies⁸⁻¹⁰ suggest that improving the availability of bedside procedures may lead to an increase in their demand, regardless of whether such an increase benefits patients.¹¹

Therefore, we sought to determine the impact of a bedside procedure service on the baseline number of paracenteses, thoracenteses, lumbar punctures (LPs), and central venous catheterizations (CVCs) performed on general medicine inpatients at our teaching hospital. In addition, we examined whether this service leads to more successful and safe procedure attempts.

METHODS

Design and Setting

In this prospective cohort study, the cohort was all patients admitted to the general medicine service at Cook County Hospital, a 500-bed public teaching hospital in Chicago, Illinois, in January and February of 2006. The general medicine inpatient service is divided into 3 firms (A, B, and C), each with 4 separate teams of physicians and students. Admissions from the emergency department or other services in the hospital, such as intensive care units (which are "closed" and therefore staffed by separate teams of physicians), are distributed in sequence to on-call teams from each firm. During the study period, the availability of a bedside procedure service varied by firm. Throughout the first 4 weeks, the service was available to only 1 of 3 firms (firm A). Then, during weeks 5 through 8, the service crossed over to the other 2 firms (firms B and C) and was unavailable to the original firm. Firm assignments for residents assigned to the inpatient service for all 8 weeks did not change. Of the 16 residents assigned to firm A during the first 4 weeks, when the procedure service was available, 3 remained on the wards during the second 4 weeks, when the procedure service was not available.

We chose to collect data on 4 bedside procedures: paracentesis, thoracentesis, LP, and CVC. Similar to those at other teaching hospitals, our residents informally acquire the skills to perform these procedures while assisting and being assisted by more experienced senior residents in a "see one, do one, teach one" apprenticeship model of learning.⁴ To improve the training and performance of

these bedside procedures, the Department of Medicine piloted a bedside procedure service to teach procedural skills and assist residents during these procedures. Use of the service, though voluntary, was actively encouraged at residents' monthly orientation meetings and regular conferences.

One attending inpatient physician (J.A.) staffed the bedside procedure service, which was available during normal work hours on weekdays. Requests for procedures were made by general medicine residents through an online database and, after approval by the procedure service attending physician, were performed under his direct supervision. A hand-carried ultrasound (MicroMaxx™, Sonosite, Inc., Bothell, WA) that generates a 2-dimensional gray-scale image was used to both confirm the presence and location of fluid prior to paracentesis and thoracentesis and provide real-time guidance during central venous catheterization. When the bedside procedure service was unavailable, residents performed bedside procedures in the usual fashion, typically without direct attending physician supervision. But if requested, an on-call chief medical resident with access to a hand-carried ultrasound device used by the intensive care unit was available for assistance at any time.

Subjects

The study subjects were all patients admitted to the general medical service during the 8-week pilot period. Patients were excluded if they had been discharged before arrival on the medical wards or if they were under the care of the general medicine service for less than 6 hours before discharge or transfer to another service. We chose 6 hours because we reasoned that such brief admissions were not potential candidates for invasive bedside procedures.

Data Collection

Each morning an investigator contacted the senior residents who had admitted patients during the previous 24-hour shift and confirmed that newly admitted patients were under the care of the general medicine service for more than 6 hours. To examine how the number of attempts may have been affected by procedures done in the emergency room or intensive care units before admission to the general medicine service, investigators also asked admitting residents whether a bedside procedure had been attempted in the 72 hours before admission. Every general medicine service resident

was asked to fill out a brief data collection form after an attempt to perform any procedure on the general medical wards. In addition, chief residents asked each member of the general medicine service at mandatory “sign-out” rounds at the end of each weekday whether any procedures had been attempted, and on weekend days investigators contacted senior residents from each general medicine service team.

We report on this quality assurance study, which was conducted during a pilot phase. This report has been reviewed and judged exempt by our institutional review board.

Primary Outcome—Number of Procedure Attempts

For all bedside procedures attempted by residents on the general medical wards, investigators determined whether the residents were members of firms that were offered the bedside procedure service and, if so, whether the procedure service attending directly supervised the procedure attempt. Multiple procedure attempts of the same type were counted for an individual patient if (1) the procedure attempts did not occur during the same admissions and (2) neither the physicians attempting the procedure nor the primary indications for it were the same. Therefore, neither attempts performed after initially unsuccessful ones nor repeated procedures, such as large-volume therapeutic paracentesis and thoracentesis, were counted twice. We reasoned that when these criteria were met, procedure attempts could be considered independently.

Secondary Outcomes

Investigators asked residents who attempted procedures to indicate whether (1) the indication for the procedure was solely diagnostic or was, at least in part, therapeutic; (2) the procedure was successful; and (3) there were any immediate major periprocedural complications. A procedure was considered to have been successfully performed if it fulfilled 2 criteria: it had to be completed during a single continuous attempt, even if multiple sites or procedure kits were used; and it had to fulfill the indication for it being done. For example, if the indication for thoracentesis was therapeutic, this procedure would be considered successful if it yielded a large enough volume of fluid to alleviate the patient’s symptoms, but if the indication was

diagnostic, then thoracentesis would be considered successful if it yielded enough fluid for laboratory processing. Residents were asked to report any periprocedural complications that they considered major; 2 illustrative examples were provided: a pneumothorax and severe bleeding.

Data Analyses

On the basis of earlier pilot data, we estimated that 8%-10% of all admissions to the general medicine service underwent at least 1 procedure (paracentesis, thoracentesis, lumbar puncture, or central vein catheterization). We planned for a sample size of 1900 admissions, which would have 80% power to detect a clinically meaningful 50% relative increase in the mean number of bedside procedures with a double-sided alpha error of 0.05. We used permutation tests to compare the mean number of procedures attempted between firms and bootstrap simulation to construct 95% confidence intervals for those means and the differences between and ratios of them. Fisher’s exact test was used to compare proportions of successfully performed procedures and preadmission procedure attempts. All analyses were conducted with Stata Statistical Software, Release 9 (StataCorp, LP, College Station, TX).

RESULTS

Subjects

During this 8-week pilot study, there were 2157 admissions to the general medicine service. Among these admissions, 216 were excluded from our study because the patients did not arrive on the medical wards or were not under the care of the general medicine service for at least 6 hours before discharge or before being transferred to another service. Of the remaining 1941 admissions, 935 were to firms with the bedside procedure service available, and 1006 were to firms without the service available (Fig. 1)

Primary Outcome—Number of Procedure Attempts

Overall, 122 patients underwent 145 procedure attempts that met our criteria for independence. The mean number of procedure attempts in firms offered the bedside procedure service was 48% higher (90 versus 61 per 1000 admissions; RR 1.48, 95% CI 1.06-2.10; $P = .030$; Fig. 1). When procedures attempted on weekends and holidays were excluded, the relative increase in procedure attempts in firms offered the bedside procedure service was even

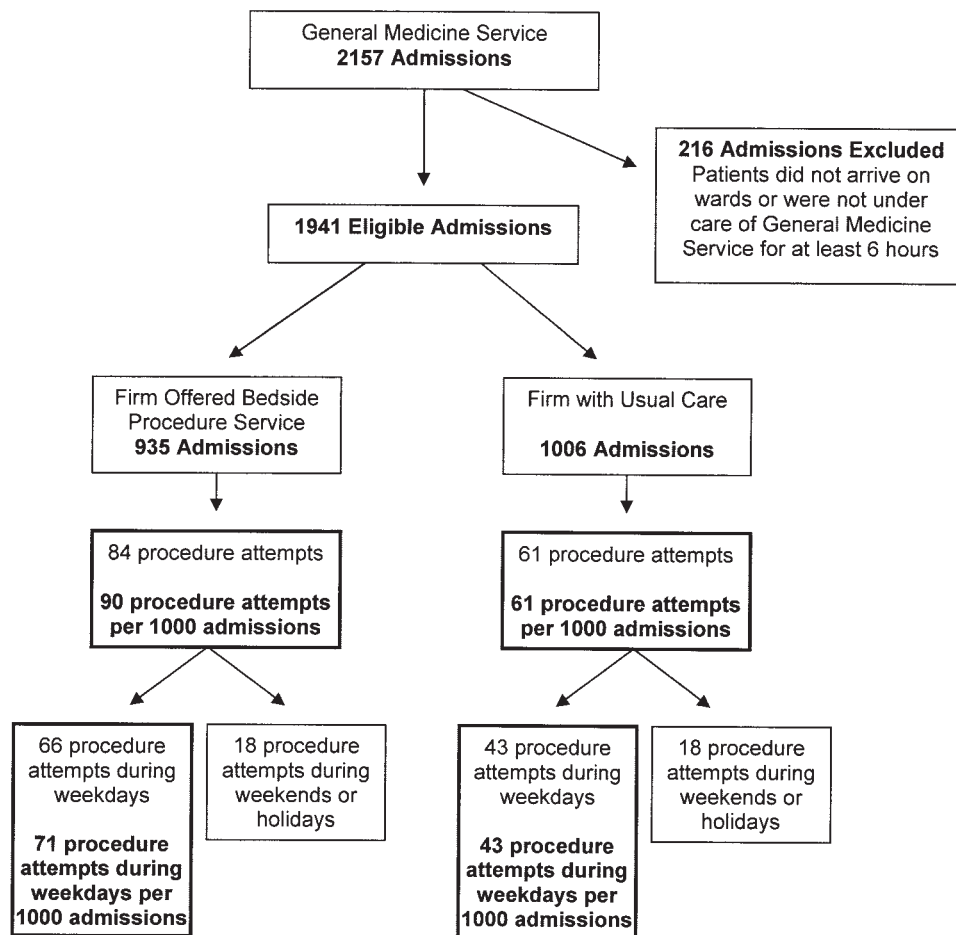


FIGURE 1. Study flow diagram and primary outcome.

higher (70 versus 43 per 1000 admissions; RR 1.63, 95% CI 1.09-2.49; $P = .023$; Fig. 1). When grouped according to whether procedure attempts occurred before or after crossover of the procedure service, the mean number of procedure attempts in firms was higher when the service was offered: firm A dropped from 84 to 70 per 1000 admissions ($P = .58$) after losing the service, whereas firms B and C increased from 57 to 94 per 1000 admissions ($P = .025$) on gaining the service. There were 40 procedure attempts performed on patients within 72 hours before admission, but there was no difference between firms in the proportions of these preadmission procedures ($P = .43$).

Secondary Outcomes

Table 1 shows how of each type of procedure contributed to the overall difference. Attempts of CVC and therapeutic paracentesis and thoracen-

tesis accounted for 86% of the overall increase in procedure attempts for admissions to firms offered the bedside procedure service, whereas only 14% of this increase was a result of diagnostic procedures. There were no differences in the proportions of successfully performed procedures, whether grouped by firm ($P = 1.0$) or by direct supervision from the procedure service attending ($P = .64$; Table 2). There were 3 self-reported major periprocedural complications; all were related to excessive bleeding from CVC attempts. Two occurred without direct supervision from the bedside procedure service attending, one hemomediastinum from an internal jugular CVC attempt and one groin hematoma from a femoral CVC attempt. The third, a groin hematoma from a femoral CVC attempt, occurred during direct supervision from the bedside procedure service attending.

TABLE 1
Rate of Procedure Attempts (per 1000 admissions) for Firms with Bedside Procedure Service and for Firms with Usual Care

Bedside procedure and indication	Firms with bedside procedure service 935 admissions	Firms with usual care 1006 admissions	Absolute rate difference (proportion of overall difference)*
Total for entire study (total for weekend days and holidays)			
Total	90 (19)	61 (18)	29 (100%)
Thoracentesis	30 (10)	18 (7)	12 (41%)
Diagnosis	9 (5)	6 (2)	3 (9%)
Treatment	21 (4)	12 (5)	9 (32%)
Paracentesis	32 (5)	25 (6)	7 (25%)
Diagnosis	9 (1)	11 (3)	-2 (-8%)
Treatment	24 (4)	14 (3)	10 (33%)
Central venous catheterization	17 (3)	11 (4)	6 (21%)
Lumbar puncture	11 (1)	7 (1)	4 (13%)
Diagnosis	10 (1)	6 (1)	4 (13%)
Treatment	1 (0)	1 (0)	0 (0%)

*Absolute differences and proportions are subject to rounding errors. *P* value for overall mean difference was .030. All subgroup *P* values > .05.

TABLE 2
Proportions of Procedure Attempts Successful by Availability of Procedure Service and Direct Supervision by Procedure Service Attending*

	Admission to firm with						<i>P</i> value of difference in proportions
	Procedure service available			Usual care			
	Total attempts (n)	Successful		Total attempts (n)	Successful		
	n	%		n	%		
Central venous catheterization	16	13	81	11	9	82	1.00
Paracentesis, thoracentesis, or lumbar puncture	68	54	79	50	40	80	1.00
Total	84	67	80	61	49	80	1.00

	Procedure service attending [†]						<i>P</i> value of difference in proportions
	Directly supervised			Did not directly supervise			
	Total attempts (n)	Successful		Total attempts (n)	Successful		
	n	%		n	%		
Central venous catheterization	10	10	100	17	12	71	0.28
Paracentesis, thoracentesis, or lumbar puncture	40	33	83	78	61	78	0.12
Total	50	43	86	95	73	77	0.64

*Two successful procedure attempts in firms with usual care were performed by Firm A residents who had been supervised by the procedure service attending while attempting the same type of procedure before the crossover.

[†]Of the 84 procedures attempted by firms offered the bedside procedure service, 34 were without direct supervision from the bedside procedure service attending, because the procedures were performed during the weekend (18), performed urgently during off-hours (13), or requested too late in the day (3).

DISCUSSION

We found that the mean number of bedside procedures increased by 48% (95% CI, 6% to 110%) from 61 to 90 per 1000 general medicine admissions when firms were offered a bedside procedure ser-

vice. This suggests that a procedure service may lead to an increase in the number of procedures performed. For example, in our hospital, where 12,500 patients are admitted annually to the general medical service, 365 additional procedures per year

(95% CI, 45-840) may be performed if a procedure service is available. Despite this potential increase in demand, we were unable to demonstrate a parallel increase in bedside procedure success, even when the procedure service attending was directly supervising residents (Table 2). Though our conclusions may not be applicable to other settings, this study is, to our knowledge, the first to describe the demand for bedside procedures performed on general medicine inpatients at an urban teaching hospital and the first to demonstrate that this demand increases with the availability of a procedure service.

Because 86% of the observed increase in procedure attempts was due to therapeutic indications (Table 1), most of the observed difference may be due to undertreatment in the usual care cohort, overtreatment in the bedside procedure service cohort, or a combination of both. However, our study was not designed to determine if patients were undertreated because we did not review the appropriateness of physicians' decisions to *not* attempt procedures. And even though the bedside procedure service attending physician prospectively confirmed the appropriateness of each procedure attempt in that cohort, we did not examine what physicians' baseline treatment thresholds were or if they were lowered by the availability of the bedside procedure service.¹¹ In other words, we cannot claim that the observed increase in procedure attempts was indicated based on patients' clinical factors. Nevertheless, the observed increase supports the important idea that discrete physician-level decisions, in this case, whether to perform a bedside procedure, may be affected by broader system-wide adoptions of new technologies like our bedside procedure service.¹² Other nonclinical factors not observed in our study, such as fee-for-service compensation and variable physician-level diagnostic and therapeutic thresholds, may also affect the rate of bedside procedures.

Our study had several limitations. We studied only one group of patients at one hospital: admissions to physicians in different settings may have different rates of bedside procedures. Our study design was observational. However, the predetermined sequential allocation of admissions and the varied assignments of the bedside procedure service during the study period should have limited selection bias. Our identification of procedure attempts, particularly in the usual care group, relied

on resident physicians' self-reports, and we cannot exclude a reporting bias. However, we believe that the daily interactions between investigators and residents from each team on the general medicine service limited the number of procedure attempts that went unrecorded. Finally, though sufficiently powered to determine our primary outcome, our study was underpowered to confirm statistical differences between firms in proportions of successfully performed procedures. For example, approximately 400 additional procedures (or more than 5000 additional admissions) would have been needed to sufficiently power the observed 9% increase in successful attempts that we observed with direct supervision by the procedure service attending (77% versus 86%; $P = .64$; Table 2). Our current sample size may be adequate in future research if success rates diverge as the experience of the procedure service attending increases. Though expert in *performing* bedside procedures, he had limited experience *teaching* them, particularly with the use of a hand-carried ultrasound device. Just as there is a learning curve to gain the experience to successfully perform procedures,¹³ so may there be a learning curve to successfully teach procedures.¹⁴

Future research could address these limitations by more closely observing the decision-making processes of physicians who order bedside procedures for general medicine inpatients in various settings. Our findings suggest that although patients' clinical circumstances are likely the most important consideration, nonclinical factors may also affect physicians' decisions.¹² Like other multifaceted decision-making processes of physicians,¹⁵ the complexity of this decision is important to examine because, as our pilot data suggest, a procedure service may not lead to more successful procedure attempts or reductions in the number of major complications. Although the cumulative expertise of our service or the innovative methods of training of other institutions may improve the performance of bedside procedures,^{5,13} physicians' decisions about whether to order them will remain paramount, because any improvement in procedural competence will do little to reduce the relative danger of unnecessary procedures¹⁶ or the missed benefit of procedures left undone. Physicians of inpatients^{17,18} should refine the indications for and anticipated benefits from these commonly performed invasive procedures.

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Procedural Training at a Crossroads: Striking a Balance between Education, Patient Safety, and Quality

“**S**ee one, do one, teach one” is a refrain familiar to all physicians. Historically, most procedural training has occurred at the bedside. In this model, senior residents, subspecialty fellows, or faculty members would demonstrate procedural skills to junior trainees, who would subsequently practice the procedures on patients, often with uneven, risky results. Acquisition of procedural skills by residents and fellows on inpatient wards is suboptimal for at least 2 reasons beyond the risks to patient safety: (1) clinical priorities are more important than educational priorities in this setting, and (2) the patient, not the medical learner, is the “most important person in the room.”

Recently, several new factors have challenged the traditional medical education model. For a variety of reasons, general internists currently perform far fewer invasive procedures than they used to.¹ A heightened focus on patient safety and quality raises questions about the qualifications needed to perform invasive procedures. Assessment requirements have also become more stringent. The Accreditation Council for Graduate Medical Education (ACGME) now requires the use of measures that yield reliable and valid data to document the competence of trainees performing invasive procedures.² In 2006 these factors, and the challenge to educate, assess, and certify residents, prompted the American Board of Internal Medicine to revise its certification requirements and remove the need for technical proficiency in several procedures including paracentesis, central venous catheter placement, and thoracentesis.^{3,4}

Two studies reported in this issue of the *Journal of Hospital Medicine* highlight important issues about preparing residents to perform invasive procedures. These include the educational limits of routine clinical care and the challenge to design rigorous educational interventions that improve residents' skills. Miranda and colleagues⁵ designed a clinical trial to evaluate an educational intervention in which residents practiced insertion of subclavian and internal jugular venous catheters under the supervision of a hospitalist faculty member. The goal was to reduce the frequency of femoral venous catheters placed at their institution. Although residents demonstrated increased knowledge and confidence after the educational intervention, the actual number of subclavian and internal jugular venous catheter insertions was lower in the intervention group, and was rare overall. The intervention did not

achieve the stated goal of reducing the number of femoral venous catheters placed by residents. This research highlights that residents cannot be trained to perform invasive procedures through clinical experience alone. In addition, it demonstrates that brief educational interventions are also insufficient. Whether a longer and more robust educational intervention might have shown different results is uncertain, but many experts believe that opportunities for deliberate practice⁶ using standardized and sustained treatments⁷ can be a powerful tool to boost the procedural skills of physicians.

At the same institution, Lucas and colleagues studied the impact of a procedural service on the number of invasive procedures performed on a general medicine inpatient service.⁸ They found a 48% increase in procedure attempts when the procedure service staffed by an experienced faculty member was available. However, no improvement in success rate or reduction in complications was demonstrated. Thus, opportunities for trainees to perform procedures increased, but the presence of a faculty member to provide direct supervision did not improve the quality of the procedures accomplished.

Together these reports highlight challenges and opportunities in training residents to perform invasive procedures. Both studies involved the procedural skills of residents. One used an educational intervention, the other featured faculty supervision. Both studies produced outcomes that suggest improved procedural training, but neither improved the actual quality of delivered care. A brief educational intervention increased resident confidence and knowledge but did not increase the quality or number of procedures performed by residents. Opportunities to perform invasive procedures increased dramatically when an experienced attending physician was available to supervise residents. However, more education was not provided, and the quality of procedures performed did not improve.

Given these limitations, how should physicians learn to perform invasive procedures? We endorse a systematic approach to achieve high levels of procedural skills in resident physicians. First, procedures should be carefully selected. Only those essential to future practice should be required. If possible, opportunities should be available for selected trainees to develop skills in performing additional procedures relevant to their future careers. An example would be the opportunity for residents

in a hospitalist track to develop proficiency in central venous catheter insertion through clinical experience, didactic education, and rigorous skill assessment. Second, dedicated programs are needed to train and assess residents in procedural skills. Reliance on clinical experience alone is inadequate because of the low frequency at which most procedures are performed and the inability to standardize assessments in routine clinical practice.

Simulation technology is a powerful adjunct to traditional clinical training and has been demonstrated to be highly effective in developing procedural skills in disciplines such as endoscopy⁹ and laparoscopic surgery.¹⁰ At our institution, a simulation-based training program has been used to help residents achieve¹¹ and maintain¹² a high level of skill in performing advanced cardiac life support procedures. We use simulation to provide opportunities for deliberate practice in a controlled environment in which immediate feedback is emphasized and mastery levels are reached. The rigorous curriculum is standardized, but learner progress is individualized depending on the practice time needed to achieve competency standards.

Most important, when training physicians to perform invasive procedures, it is critical to use interventions and training programs that can be linked to improvements in actual clinical care. The studies by Miranda et al. and Lucas et al. highlight the utility of focused educational programs to complement clinical training as well as the positive impact of direct faculty supervision. These results are important starting points for programs to consider as they train and certify residents in required procedural skills. However, much work remains to be done. These studies have revealed that improvements in patient care outcomes are not likely to occur unless robust, learner-centered educational programs are combined with adequate opportunities for residents to perform procedures under appropriate supervision.

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