The Journal of Emergency Medicine, Vol. xx, No. x, pp. xxx, 2008
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0736-4679/08 $–see front matter

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doi:10.1016/j.jemermed.2007.11.054

# Selected Topics: Prehospital Care

# WHEN ARE PREHOSPITAL INTRAVENOUS CATHETERS USED FOR TREATMENT?

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☐ **Abstract—Prior studies have found that > 50% of prehospital intravenous catheters (i.v.s) were unutilized for treatment; however, few data are available regarding which patients benefit. The objective of this study was to examine the association between i.v. utilization in the field, paramedic primary impression, and patient presentation. Prehospital records for 34,585 patients were evaluated for i.v. placement and utilization in the field. Logistic regression was used to evaluate the association of primary impression, systolic blood pressure, heart rate, respiratory rate, Glasgow Coma Scale score, skin sign color, and capillary refill with placement and utilization. Intravenous catheters were placed in 60% of patients, but only 17% of the total was utilized. Examples of primary impressions with frequent initiation and low utilization (n = number in group, % of total with i.v. placed, % of total used): post-seizure (n = 989, 72%, 9%); weakness/dizzy/nausea (n = 3092, 69%, 20%), syncope/near-syncope (n = 2034, 81%, 26%), and abdominal pain (n = 1554, 70%, 14%). Fifty-eight percent with normal vital signs received an i.v. and 28–30% were utilized; hypotension: 80% received i.v. (odds ratio [OR] 1.211, $p = 0.012$), 70% utilized; hypertension: 61% received i.v. (OR 1.060, $p = 0.027$), 28% utilized; bradycardia: 82% received i.v. (OR 1.588, $p < 0.0001$), 51% utilized; tachycardia: 66% received i.v. (OR 1.152, $p = 0.001$), 33% utilized; bradypnea: 93% received i.v. (OR 1.638, $p = 0.051$), 86% utilized; tachypnea: 70% (OR 1.120, $p = 0.024$), 33% utilized. A Glasgow Coma Scale score < 15: 76% received i.v. (OR 1.672, $p < 0.0001$), 32% utilized. Abnormal skin color: 79% received i.v. (OR 1.691, $p < 0.0001$), 42% utilized. Certain primary impressions are associated with high i.v. initiation rates but infrequent utilization. High utilization rates were associated with hypotension, bradycardia, bradypnea, and abnormal skin signs. Study of high-frequency, low-utilization groups could reduce unnecessary i.v. placement.** **© 2008 Elsevier Inc.**

☐ **Keywords—Emergency Medical Services; paramedic; peripheral intravenous catheter; infusions; intravenous; Emergency Medical Technicians; utilization**

## INTRODUCTION

One of the most common Emergency Medical Services (EMS) procedures performed is placement of intravenous (i.v.) catheters. Studies have shown that the regional variation in the rate of i.v. catheter placement ranges from 15% to 86% (1–4). Two prior studies that looked at prehospital i.v. catheter placement found that a high percentage of catheters were not ultimately used for treatment.

Dr. Sporer receives compensation for medical direction from American Health and Safety Training, Inc. and the San Mateo Emergency Medical Services Agency.

RECEIVED: 26 March 2006; FINAL SUBMISSION RECEIVED: 25 June 2007;
ACCEPTED: 6 November 2007

The decision to place an i.v. should be based on whether the i.v. will be used in the field or in the Emergency Department (ED) and whether there is benefit over the whole continuum of care. There are limited data regarding rates of catheter utilization in hospitalized or ED patients.

This study examined the likelihood that an i.v. would be used by paramedics for treatment during ambulance transport by comparing i.v. placement and utilization rates for specific categories of paramedic primary impression, patients' vital signs, skin signs, and Glasgow Coma Scale score (GCS). Gender, age, and race were also analyzed as confounding factors that might influence the rate of i.v. placement.

## METHODS

This retrospective study was conducted in an urban/suburban county with a population of 700,000 and an area of 552 square miles that receives approximately 30,000 calls and 20,000 transports for emergency medical assistance annually. All calls receive Advanced Life Support response under a single-tiered system, consisting of a fire department single-paramedic first-response team and an Emergency Medical Technician/Paramedic-staffed private transport ambulance. Paramedics complete an electronic medical record for each patient encounter. The electronic medical record has over 200 searchable elements, including paramedic impression, vital signs, skin signs, GCS, and treatment. Data were extracted for patients transported by ambulance during the 2-year period from January 2004 through December 2005, for a total of 39,654 electronic patient records. There were 36,926 cases documented as code 2 (normal flow of traffic) transport to the hospital and 2728 documented as code 3 (lights and sirens) transport to the hospital. There were 5069 records excluded (12% code 2 and 19% code 3 transports) due to missing data or typographical error, leaving a total of 34,585 records. This study was approved by the University of California, San Francisco Committee on Human Research.

Patients were then evaluated for the presence of a utilized i.v. catheter, an unutilized i.v. catheter, and no i.v. catheter. Although 36% of the i.v. catheters in this system are saline locks rather than i.v. lines, no distinction was drawn between these groups. An i.v. catheter was considered to have been utilized if a fluid bolus was administered (at least 250 cc of normal saline, or documentation of the i.v. line run "wide open") or documented administration of any of the following drugs: adenosine, atropine, benadryl, sodium bicarbonate, dextrose, dopamine, epinephrine, lidocaine, morphine, naloxone, nitroglycerin, and midazolam. Some medications that defined i.v. usage in this study may also be given subcutaneously or intramuscularly by EMS protocol: epinephrine, benadryl, naloxone, morphine, and midazolam. Although this may artificially inflate usage numbers in some primary impression categories, the route of choice is most often intravenous. Patients that received a medication defined as an i.v. medication but did not have an i.v. were assigned to the "no i.v. placed" category. Patients for whom an i.v. was attempted but not successfully placed were also included in the "no i.v. placed" category.

Records were also evaluated based on the paramedic's "primary impression," which is chosen from a drop-down list. Categories that had fewer than 50 patients were combined with related complaints, which created 38 primary impression categories used for the study.

Logistic regression analysis (SPSS software; SPSS Inc., Chicago, IL) was used to control for age, race, and gender, paramedic primary impression, systolic blood pressure (SBP), heart rate (HR), respiratory rate (RR), GCS, skin sign color, and capillary refill. Vital signs were categorized as follows: initial SBP (low $< 90$, normal 90–140, high $< 140$), HR (slow $< 60$ beats/min, normal 60–119 beats/min, fast $> 119$ beats/min), RR (slow $< 12$ breaths/min, normal 12–24 breaths/min, fast $> 24$ breaths/min) GCS (15, or $< 15$), skin sign color, cap refill, and code of transport.

## RESULTS

Of 34,585 records, an i.v. catheter was initiated in 20,732 patients (60%). When an i.v. catheter was placed, it was utilized to administer medication, fluid, or was associated with nitroglycerin administration in 6157 patients (17%). The average age for patients who received an i.v. catheter was 60 years, and 52 years for patients who did not receive an i.v. catheter. Age was statistically significant for i.v. placement ($p < 0.0001$) and utilization for treatment ($p < 0.0001$) (Table 1). Children under 14 years of age made up 3.3% of the study population, and they were half as likely as adults to receive an i.v. The utilization rates of i.v. catheters in adults and children were both about 17%.

Gender was statistically significant in the decision to initiate an i.v. catheter, but was not significant for treatment ($p = 0.395$). The proportion of males with i.v. placement was 61.7%, females 58.4% (odds ratio [OR] 0.816, $p < 0.0001$). There was a lower rate of i.v. initiation noted among African-Americans and Pacific Islanders (Table 1).

**Table 1. Patient Demographics of i.v. Placement and Utilization**

| Variable | Number of Patients (%) | i.v. Placement (%) | Odds Ratio (p Value) | i.v. Utilization for Treatment (%) | Odds Ratio (p Value) |
|---|---|---|---|---|---|
| Age | | | | | |
| Adult | 33453 (96.7) | 20,366 (60.9) | | 6046 (29.7) | |
| Child (<14 years) | 1132 (3.3) | 366 (32.3) | NC | 110 (30.1) | NC |
| Gender | | | | | |
| Male | 16162 (46.7) | 9967 (61.7) | 1.000 | 3022 (30.3) | 1.000 |
| Female | 18423 (53.3) | 10,765 (58.4) | 0.816 (< 0.0001) | 3134 (29.1) | 1.031 (0.395) |
| Race | | | | | |
| Caucasian | 16429 (47.5) | 10,285 (62.6) | 1.000 | 3117 (30.3) | 1.000 |
| African-American | 2456 (7.1) | 1259 (51.3) | 0.652 (<0.0001) | 409 (32.5) | 1.090 (0.256) |
| Asian | 2483 (7.2) | 1565 (63.0) | 1.051 (0.319) | 460 (29.3) | .831 (0.008) |
| Hispanic | 3748 (10.8) | 2174 (58.0) | 1.095 (0.031) | 608 (30.0) | .864 (0.020) |
| Native-American | 17 (0.05) | 9 (52.9) | 0.714 (0.528) | 4 (44.4) | 2.112 (0.312) |
| Pacific Islander | 981 (2.8) | 562 (57.3) | 0.777 (0.001) | 170 (30.3) | 1.002 (0.987) |
| Unknown/other | 8471 (24.5) | 4878 (57.6) | 0.840 (<0.0001) | 1388 (28.5) | .838 (<0.0001) |
| Transport level | | | | | |
| Code 2 | 32378 (93.6) | 18,903 (58.4) | 1.000 | 5186 (27.4) | 1.000 |
| Code 3 | 2207 (6.4) | 1829 (82.9) | 2.009 (<0.0001) | 970 (53.0) | 2.030 (< 0.0001) |

When analyzed by multiple logistic regression, abnormal vital signs had statistically significant higher rates of i.v. placement as well as utilization rates (Table 2). For i.v. initiation and utilization, all abnormal categories except bradypnea were statistically significant ($p$ = 0.051). Although placement rates increased with abnormal vital signs, i.v. utilization rates were not much different among hypertensive, tachycardic, or tachypneic groups compared with patients in the normal range; i.v. initiation and utilization rates were significantly higher for hypotensive, bradypneic, and bradycardic patients, with 51% of i.v.'s utilized for bradycardic patients (OR 1.474, $p < 0.0001$), 70% for hypotensive patients (OR 4.256, $p < 0.0001$), and 86% for bradypneic patients (OR 3.850, $p < 0.0001$).

Patients with abnormal skin signs were statistically more likely to have an i.v. placed (OR 1.691, $p < 0.0001$) as well as utilized (OR 1.596, $p < 0.0001$). Prolonged capillary refill did not seem to influence the decision to initiate an i.v., nor was it statistically significant (OR 1.075, $p = 0.390$). It was, however, associated with high rates of treatment once an i.v. was placed (OR 1.430, $p < 0.0001$) (Table 2). Perhaps more interesting, altered mental status as reflected by a GCS < 15 was associated with relatively high rates of i.v. placement (75.5%, OR 1.672, $p < 0.0001$), but rates of utilization were similar to patients with normal mentation (32.3%, OR .920, $p = 0.112$).

Figure 1 demonstrates the absolute number of i.v. catheters placed and the number used to treat by primary im-

**Table 2. Correlation of Paramedic Initial Finding with i.v. Placement and Utilization**

| Initial Finding | Categories | Number of Patients (%) | i.v. Placement (%) | i.v. Start Odds Ratio (p Value) | i.v. Utilization for Treatment (%) | i.v. Used Odds Ratio (p Value) |
|---|---|---|---|---|---|---|
| Blood pressure (SBP) | Normal SBP (90–140 mmHg) | 19,127 (55.3) | 11,012 (57.6) | 1.000 | 2969 (30.0) | 1.000 |
| | Hypotensive (<90 mm Hg) | 1490 (4.3) | 1195 (80.2) | 1.211 (0.012) | 800 (70.0) | 4.256 (<0.0001) |
| | Hypertensive (>140 mm Hg) | 13,968 (40.4) | 8525 (61.0) | 1.060 (0.027) | 2387 (28.0) | .937 (0.096) |
| Heart rate (HR) | Normal HR (60–119) | 29,266 (84.6) | 16,989 (58.1) | 1.000 | 4732 (27.9) | 1.000 |
| | Bradycardia (<60) | 1366 (4.0) | 1123 (82.2) | 1.588 (<0.0001) | 569 (50.7) | 1.476 (<0.0001) |
| | Tachycardia (>119) | 3953 (11.4) | 2620 (66.3) | 1.152 (0.001) | 855 (32.6) | 1.110 (0.064) |
| Respiratory rate (RR) | Normal RR (12–24) | 30,784 (89.0) | 18,009 (58.5) | 1.000 | 5102 (28.3 | 1.000 |
| | Bradypnea (<12) | 322 (0.9) | 298 (92.5) | 1.638 (0.051) | 256 (85.9) | 3.850 (<0.0001) |
| | Tachypnea (>24) | 3479 (10.1) | 2425 (69.7) | 1.120 (0.024) | 798 (32.9) | 1.246 (0.001) |
| Skin signs | Normal color | 28,040 (81.1) | 15,533 (55.4) | 1.000 | 3988 (25.7) | 1.000 |
| | Abnormal color | 6545 (18.9) | 5199 (79.4) | 1.691 (<0.0001) | 2168 (41.7) | 1.596 (<0.0001) |
| Cap refill | ≤2 s | 33,207 (96.0) | 19,586 (60.0) | 1.000 | 5494 (28.1) | 1.000 |
| | >2 s | 1378 (4.0) | 1146 (83.2) | 1.075 (0.390) | 662 (57.8) | 1.430 (<0.0001) |
| GCS | 15 | 27,362 (79.1) | 15,312 (56.0) | 1.000 | 4406 (28.8) | 1.000 |
| | <15 | 7223 (20.9) | 5420 (75.5) | 1.672 (<0.0001) | 1750 (32.3) | .920 (0.112) |

i.v. = peripheral intravenous catheter; GCS = Glasgow Coma Scale score.

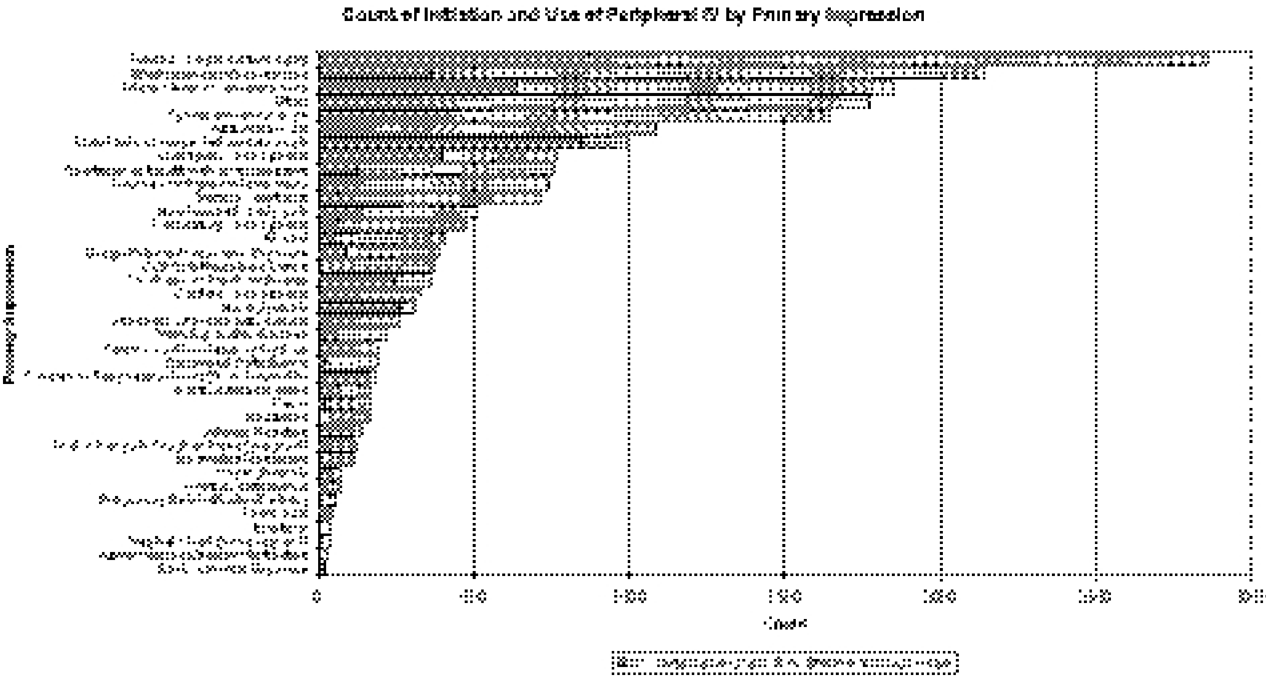

**Figure 1. Number of peripheral i.v.'s placed and used for treatment by primary impression.**

pression category. Some primary impressions have very high rates of i.v. placements, but are frequently not utilized for treatment. Figure 2 demonstrates the percentage of i.v.'s utilized for treatment by primary impression category.

## DISCUSSION

The decision to start an intravenous line in the field obviously takes into account many variables, including

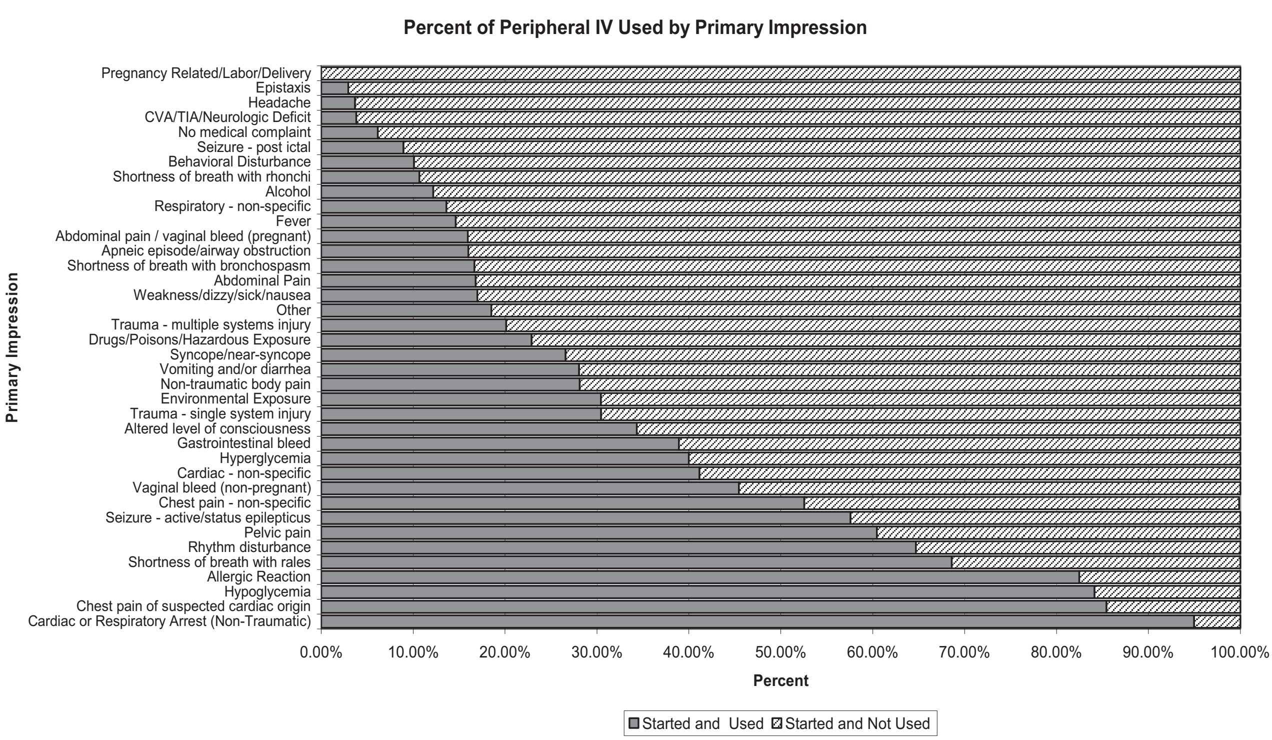


**Figure 2. Percent of peripheral i.v. used for treatment by primary impression.**

the physical presentation of the patient initially and the paramedics' working differential diagnosis. The patient's initial vital signs and appearance may change rapidly from initial contact to the arrival at the hospital. The paramedic working alone in the back of the ambulance may elect to start a more aggressive treatment as a precaution against an acute change en route to the hospital to save time or in anticipation of therapy in the hospital that is not available in the field.

Our study was consistent with the findings of Pace et al. that there are significant numbers of i.v. catheters placed and not utilized (5). This study defined appropriate i.v. catheter placement as one used by the paramedics or used within 1 h of admittance to an ED. The study found an overall i.v. catheter initiation rate (including unsuccessful attempts) of 57% of 290 patients. Forty-nine percent of the i.v.'s placed in this study were used for treatment in the field or in the first hour in the ED (5). In another study, the i.v. catheter initiation rate was 49% of 802 EMS patients. Of 325 successful i.v. lines, 40% received an i.v. medication or nitroglycerin, 3.1% received a fluid bolus, and 2.5% received both fluid and medication, for a total utilization rate of 45.6% (6).

A retrospective study reviewed paramedics' use of i.v. lines, saline locks, and no-i.v.-placement options compared to the study protocol. Over-treatment was defined as the use of a more expensive i.v. option than indicated by the study protocol, such as an i.v. line when a saline lock or no i.v. was indicated. The study protocol took into account the county's EMS protocol, vital signs, chief complaint, and mechanism of injury that might cause a patient to become unstable to establish the appropriate i.v. method. The over-treatment rate was 56%, and most of this occurred due to the choice of an i.v. line over a saline lock (4).

A recent prospective study examined the i.v. placement and utilization in the French EMS system, which staffs physicians on the ambulances (7). Physicians responding to emergencies elected to initiate i.v.'s for 58% of the patients, similar to the rate initiated by paramedics in the United States; however, 71% of the i.v.'s in the French system were used to administer medications in the prehospital environment. The greater variety of medications available to the physician or a different patient population could account for this higher utilization.

The three concerns regarding prehospital i.v. catheter placement include delay of patient transport to the hospital, increased complication rates, and an increased risk of blood-borne pathogen exposure for the paramedic. Allen et al. found that the average time to transport without an i.v. initiated was 13.2 ± 6.4 min, and 17.4 ± 5.7 min with an i.v. (6). This included patients that received treatment and, therefore, some of the delay may include treatment time. Two prospective studies have shown that i.v. catheter placement by paramedics does not significantly delay transport to the hospital and can be performed effectively en route for trauma patients (8,9).

One study looked at i.v. catheter utilization in hospitals and found that patients admitted to regular medical wards had high rates of "idle intravenous catheters." Thirty-five percent of 484 i.v. catheters had two or more consecutive days during which they were not used (10).

There is conflicting evidence about increased complication rates associated with field i.v. catheter placement as compared to catheters placed in the ED. Lawrence and Lauro found that 34% of 191 patients with i.v. catheters placed in the prehospital setting developed phlebitis, vs. 7% for i.v. catheter placement in the ED (11). Another prospective study of 3185 patients with confirmatory wound and blood cultures demonstrated a prehospital infection rate of suppurative phlebitis and bacteremia to be .0012, compared with the ED infection rate of .0017, suggesting comparable risk in both environments (12).

Although many of the EMS protocols in our system were written to "consider i.v. access" with the desire to allow paramedics to use their judgment, there seems to be a tendency to treat conservatively. "Better to err on the side of caution" and "you can't be criticized for over-treating" are frequently repeated mantras to paramedic interns. The variability in expectation from receiving hospitals encourages paramedics to treat conservatively to avoid confrontation. Currently, there are few data as to the number of catheters that are unutilized in the ED. As noted in the recent Institute of Medicine report on the state of emergency care in the United States, ED staff work in stressful environments filled beyond capacity (13). The expectation of the hospital staff may play a role in the rate of i.v. catheter placement. A patient that arrives with an i.v. catheter established as a precaution may seem to eliminate one more task for the nursing staff.

There are some good indicators that an i.v. will be utilized for treatment in the field, such as hypotension, bradycardia, bradypnea, delayed capillary refill, and abnormal skin signs. Hypertension, tachypnea, and tachycardia by themselves are not good indicators that an i.v. will be utilized. A GCS $< 15$ did not serve as a good indicator that an i.v. would be utilized for treatment.

This study found that there were high rates of i.v. starts and utilization with cardiac/respiratory arrest, chest pain, cardiac problems, shortness of breath with rales, allergic reactions, and hypoglycemia. There are clearly groups of patients that receive high rates of unutilized i.v. catheters. Complaints such as post-ictal patients, cerebral vascular accident/transient ischemic attack, and alcohol had low rates of i.v. utilization. Respiratory complaints also had low utilization rates, with shortness-

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of-breath with bronchospasm at 17% and shortness-of-breath with rhonchi at 11%.

This study could be an initial discussion and roadmap for future clinical prehospital research into suggesting the optimal indications for i.v. placement for specific medical conditions. Future clinical protocols directing i.v. placement could be based on a specific threshold of utilization rates.

## LIMITATIONS

Unsuccessful i.v. attempts were not counted in this study. The i.v. success rate in this system is 86%, therefore, the actual i.v. attempt rate was higher. Conversely, some patients didn't receive treatment via i.v. catheter because i.v. access was not available. There was a possible bias from the number of higher acuity cases missing vital signs. Vital signs were more often left blank for code 3 transports (6% vs. 3%) possibly due to the electronic form limitation that does not allow for "unable to obtain" blood pressures as well as the practice of leaving blanks in the place of "0." The i.v. utilization rate included medications that may be administered subcutaneously or intramuscularly. This would primarily affect asthma, mild allergic reaction, and some narcotics overdoses.

There is also the possibility that the decision to place an i.v. in our private ambulance system may be driven by billing considerations. This study also did not follow-up on the rate of i.v. utilization in the ED or any complication rate.

## CONCLUSION

In this system, paramedics place many precautionary i.v. catheters that are not utilized in the field for treatment. Intravenous catheters were placed in 60% of patients, but only 17% of the total was utilized. Abnormal vital signs were associated with higher i.v. utilization rates. The i.v. placement and utilization rates varied considerably by paramedic impression. Future studies that include the frequency of ED utilization would better inform our paramedics on appropriately weighing the costs and benefits of initiating a prehospital intravenous line.

## REFERENCES

1. Shah MN, Bishop P, Lerner EB, Fairbanks RJ, Davis EA. Validation of using EMS dispatch codes to identify low-acuity patients. Prehosp Emerg Care 2005;9:24–31.
2. Shah MN, Bishop P, Lerner EB, Czapranski T, Davis EA. Derivation of emergency medical services dispatch codes associated with low-acuity patients. Prehosp Emerg Care 2003;7:434–9.
3. Michael GE, Sporer KA. Validation of low-acuity emergency medical services dispatch codes. Prehosp Emerg Care 2005;9:429–33.
4. Gausche M, Tadeo RE, Zane MC, Lewis RJ. Out-of-hospital intravenous access: unnecessary procedures and excessive cost. Acad Emerg Med 1998;5:878–82.
5. Pace SA, Fuller FP, Dahlgren TJ. Paramedic decisions with placement of out-of-hospital intravenous lines. Am J Emerg Med 1999; 17:544–7.
6. Allen B, Reisdorff EJ, D'Agostino J, Brown B, Shah CP, Thakur RK. Prehospital IV access: what is the impact? Prehosp Emerg Care 1997;3:191.
7. Minville V, Pianezza A, Asehnoune K, Cabardis S, Smail N. Prehospital intravenous line placement assessment in the French emergency system: a prospective study. Eur J Anaesthesiol 2006; 23:594–7.
8. Jones SE, Nesper TP, Alcouloumre E. Prehospital intravenous line placement: a prospective study. Ann Emerg Med 1989;18:244–6.
9. Spaite DW, Valenzuela TD, Criss EA, Meislin HW, Hinsberg P. A prospective in-field comparison of intravenous line placement by urban and nonurban emergency medical services personnel. Ann Emerg Med 1994;24:209–14.
10. Lederle FA, Parenti CM, Berskow LC, Ellingson KJ. The idle intravenous catheter. Ann Intern Med 1992;116:737–8.
11. Lawrence DW, Lauro AJ. Complications from i.v. therapy: results from field-started and emergency department-started i.v.'s compared. Ann Emerg Med 1988;17:314–7.
12. Levine R, Spaite DW, Valenzuela TD, Criss EA, Wright AL, Meislin HW. Comparison of clinically significant infection rates among prehospital-versus in-hospital-initiated i.v. lines. Ann Emerg Med 1995;25:502–6.
13. Committee on the Future of Emergency Care in the United States Health System, Institute of Medicine. Hospital-based emergency care: at the breaking point. Washington, DC: National Academies Press; 2006.