

Reducing Cost and Intravenous Duration of Nicardipine in Intracerebral Hemorrhage Patients via an Interdisciplinary Approach

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Background: The mainstay of acute management of intracerebral hemorrhage (ICH) is blood pressure reduction. Intravenous (IV) nicardipine is an effective but costly intervention for blood pressure reduction in the intensive care unit (ICU). Earlier transition to oral (PO) antihypertensive agents may reduce ICU length of stay (LOS) and associated costs. We sought to study the effectiveness of an interdisciplinary intervention to start earlier transition to PO antihypertensives. *Methods:* From July 2011 to July 2012, patients with ICH who received IV nicardipine were reviewed and screened for eligibility by an interdisciplinary team including physicians and pharmacists. These patients were compared to a control group 1 year prior to this intervention. The duration of nicardipine treatment (median hours), estimated costs, and ICU LOS were measured. *Results:* A total of 35 patients and 44 controls were studied. The median hours of IV nicardipine use were significantly decreased from a baseline mean of 118 to 30 hours ($P < .001$); total cost savings per year was \$433,566 (\$18,475 per patient). The average LOS remained similar (8.4 versus 8.9 days, $P < .990$). In a follow-up study 1 year later, after the intervention was no longer used, a sample of 21 consecutive patients was reviewed and the duration of IV nicardipine treatment had increased to a mean of 96 hours. *Conclusion:* A physician and pharmacist-led project to initiate oral antihypertensive medications earlier was successful in reducing the duration of IV nicardipine treatment in patients with ICH while leading to substantial cost savings. **Key Words:** Stroke—intracerebral hemorrhage—neurocritical care—cost-effectiveness—quality improvement—ICH—nicardipine—neuro-ICU.
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Introduction

Intracerebral hemorrhage (ICH) accounts for approximately 15% of patients with stroke and is associated with a higher mortality than ischemic stroke.¹⁻³ The mainstay of acute management of ICH in patients without coagulopathy is blood pressure control as uncontrolled hypertension is associated with neurological deterioration within the first 24 hours due to hematoma expansion.^{4,5}

There is a significant need to rationally and safely decrease healthcare resource utilization in ICH.⁶⁻⁸ The acute hospitalization cost of ICH is approximately \$32,000, over one third higher than ischemic stroke.⁹ However, this figure does not account for associated costs of long-term medications and other aspects of ICH-related care. Long-term costs at 10 years have also been shown to be significantly higher than ischemic stroke.¹⁰

Intravenous (IV) nicardipine is effective for acute blood pressure lowering in patients with ICH and has been favored over other IV medications due to decreased lability and faster time to achieving targeted goals.^{5,11-14} However, IV nicardipine is a high-cost medication and requires intensive care unit (ICU) monitoring. Appropriately transitioning quickly from IV nicardipine to oral (PO) antihypertensive therapy provides an opportunity to expedite transfer out of the ICU.¹⁵ We hypothesized that pharmacist-led interdisciplinary management would reduce ICU stay and associated costs.

We sought to study whether an interdisciplinary approach could decrease IV nicardipine utilization while minimizing cost and reducing ICU stay.

Methods

From July 2011 to July 2012, patients with ICH who were administered IV nicardipine at the University of California San Francisco were reviewed and screened for eligibility by a multidisciplinary team including a physician and pharmacist as approved by the Committee on Human Research. ICH patients were included in the study if they were older than 18 years old and received at least 1 dose of IV nicardipine (40 mg/200 mL) with a diagnosis of intra-axial ICH made via imaging. These patients were compared to ICH patients admitted in 2010 as controls.

The primary outcomes examined were decreased use of nicardipine and cost savings in comparison to controls from the year prior.

The multidisciplinary approach used included a pharmacist and all physicians involved in the care of patients admitted with new ICH. Daily assessments included determination if initiating PO antihypertensive agents were appropriate. Pharmacists followed an algorithm to determine conversion from IV to PO (see Fig 1). Other pharmacist-led interventions included education to healthcare providers and monthly reports that provided

healthcare personnel with their use of nicardipine in the previous month. An order-set for ICH patients was also initiated, which included PO alternatives to be initiated when the order for nicardipine was first written and a renewal obligation of the nicardipine order was obtained after 72 hours.

The method for initiating PO antihypertensives was determined by the treating physician, who was guided by institutional protocol recommending that ICH patients start on home medications, then daily angiotensin-converting enzyme inhibitors (ACEIs), and then other oral antihypertensives accounting for patient comorbidities.

A follow-up analysis to evaluate sustainability in 2013 was completed 1 year after the study period without multidisciplinary intervention. The duration of nicardipine treatment (median hours), estimated yearly cost, and ICU length of stay (LOS) were measured.

Statistical and Data Analysis

Data comparison between years was made using Kruskal-Wallis rank-sum test for non-normative data. Calculation of the cost per unit was performed by dividing the milligrams of a premixed bag of 40 mg/200 mL nicardipine and then multiplying by the median rate of 8 mg/hour multiplied by the median hours on nicardipine. The median rate of nicardipine was derived from the median milligram of nicardipine used in the control group. The hours on nicardipine were defined as the time between the order being written and the order being discontinued. The unit cost for IV nicardipine was \$211 in 2010-2012 and \$246 in 2013. Cost per patient accounted for these year to year differences.

Results

A total of 44 control patients with an average age of 66.1 years (standard deviation ± 15.9), of which 48% were male, admitted between 2010 and 2011, were studied. During the study period from 2011 to 2012, 35 patients with an average age of 67.7 years (standard deviation ± 17.7), of which 46% were male, were prospectively screened and studied ($P = .86$ compared with the control group gender distribution).

The median time of IV nicardipine utilization was decreased from a baseline of 118 to 30 hours during the study period ($P < .001$). The estimated yearly cost of IV nicardipine per patient decreased from \$24,684 to \$6389 during the study period (see Fig 2). The total cost savings per year was \$433,566. Average LOS remained similar (8.4 versus 8.9 days, $P < .990$) (see Table 1).

After study completion, 21 consecutive patients in 2013 (average age 61.6 ± 15.0 ; 52% male) were reviewed. The duration of IV nicardipine treatment had increased to a median of 96 hours, and cost increased to \$23,676 per patient from the study period.

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