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Prostacyclin administration errors in pulmonary arterial hypertension patients admitted to hospitals in the United States: a national survey

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BACKGROUND: Epoprostenol and treprostinil are intravenous prostacyclin medications used to treat pulmonary arterial hypertension (PAH). This survey explored hospital policies regarding prostacyclin infusions, and investigated the type and frequency of errors that occurred in the inpatient setting.

METHODS: Information on prostacyclin infusion policies and inpatient errors was obtained through detailed interviews with 18 PAH nurses, and through an electronic survey completed by 97 PAH clinicians.

RESULTS: The electronic survey respondents reported wide variability in prostacyclin infusion policies, including variability in the use of home vs hospital infusion pumps, and variability in the use and storage of back-up epoprostenol and treprostinil. Serious or potentially serious errors in medication administration were reported by 68% of survey respondents. The most common error types (reported by ≥25%), included: incorrect cassette placed in the pump; inaccurate pump programming; errant drug dosing; and inadvertent cessation of the pump. Nine errors, all at different centers, were believed to have contributed to patient death. In the separate interviews with the PAH nurses, 94% reported serious errors. These errors prompted many of the centers to implement policy changes in an attempt to reduce future errors, improve safety and optimize patient outcomes.

CONCLUSIONS: These findings suggest that prostacyclin infusion therapy is problematic and that an opportunity exists to improve safety. The development of standardized treatment guidelines should be considered.

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Pulmonary arterial hypertension (PAH) is characterized by vasoconstriction and proliferation of the small pulmonary arteries. Intravenous epoprostenol (Flolan; GlaxoSmithKline and Teva) and treprostinil (Remodulin; United Therapeutics) are continuous intravenous medications used in the most advanced cases of PAH.[1] These medications, referred to here as "prostacyclins," are administered by ambulatory infusion pumps attached to central venous catheters. Dosing is adjusted based on clinical response, side effects and symptoms. Dose changes are made in minute increments to avoid severe symptoms of toxicity, and sudden increases or decreases in the dose can be life-threatening.[2,3]

When patients require hospital admission, preparation, administration and programming of their home infusion pump becomes the responsibility of the pharmacy and nursing staff.

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Inpatient management can be challenging for nurses, because even at large PAH centers there are typically only a few inpatients receiving intravenous prostacyclin at any given time. Many nurses have had limited exposure to both the medications and the ambulatory infusion pumps. We conducted this survey to determine the type and frequency of prostacyclin administration errors in the hospital setting and to explore hospital policies regarding prostacyclin infusions.

Methods

This project consisted of two separate queries. First, nurses and nurse practitioners at 18 large pulmonary hypertension (PH) centers were interviewed by telephone. The centers were chosen based on size, experience treating PH, involvement with the Pulmonary Hypertension Association (PHA) and geographic diversity. Information on inpatient prostacyclin administration policies and any adverse events was obtained. Following this, a large-scale electronic survey was sent to a convenience sample of all PAH centers in the USA whose physicians or nurses are members of the Pulmonary Hypertension Association (PHA). Pharmacists working for Accredo, a PAH specialty pharmacy, were also included in the electronic survey. Probable recipients included approximately 420 physicians who are members of the PHA e-mailing list, 140 nurse members of the PH Resource Network and another 600 pharmacists and nurses included from a large PH specialty pharmacy database. Institutional review board approval was obtained from the University of Texas Southwestern Medical Center at Dallas prior to launching the survey. The design and completion of the survey were accomplished using the internet survey tools available at SurveyMonkey.com.[4] This electronic survey included nine questions, as shown in the Appendix, and included policy questions as well as questions on type, frequency and severity of errors. Participants had the option of leaving their medical center name and contact information, or completing the survey anonymously. The survey was opened during the month of February 2009.

Statistical analysis

The interview results for the 18 PH nurses are presented as descriptive, qualitative data. Frequency distributions for the responses to the nine electronic survey questions are reported. Chi-square or Fisher's exact tests (when expected cell values were <5) were performed to compare error rates and specific error types among centers with a policy of home infusion pump use as compared with hospital pump use. McNemar's test was performed to evaluate the storage of epoprostenol and treprostinil on nursing units. NCSS 2004 was used for the analysis. Where descriptive or qualitative information is presented, errors are not reported around each proportion. The maximum margin of error for the survey is 11%, based on between 87 and 97 responses to each individual question.

Results

Introduction and respondent characteristics

One nurse or nurse-practitioner from each of 18 pulmonary hypertension centers was approached by telephone, and all 18 agreed to be interviewed. Each of the centers included routinely utilized intravenous prostacyclins, and the nurses who were interviewed were directly involved in patient care; responses are detailed in what follows. Separately, a survey evaluating prostacyclin policies and errors across a larger and more diverse group of respondents was conducted. This survey was completed by 97 respondents from a recipient pool of up to 1,200 individuals (~8% response rate), and the respondents included 30 physicians, 18 nurse practitioners, 29 nurses, 19 pharmacists and 1 respiratory therapist.

Nursing telephone interviews

Errors and policies. Significant variability was reported in prostacyclin administration policies by the nurses and nurse-practitioners interviewed by phone. Eight of 18 respondents reported that either or both epoprostenol and treprostinil back-up cassettes or bags were kept on the nursing unit, whereas the remaining kept back-up cassettes or bags were in the pharmacy. Ten of 18 nurses reported that patients at their institution were usually or always transitioned to a hospital infusion pump, whereas 8 kept patients on their home infusion pumps.

Errors were also common, with 17 of 18 nurses reporting at least one serious error at their center, including 3 deaths. Serious errors occurred whether patients were kept on home infusion pumps or were transitioned to hospital pumps. Two error types were reported only with the use of home infusion–style pumps: failure to restart the infusion pump, and mix-up of medication cassettes. The medication cassette errors took place despite proper labeling, typically when a nurse removed a cassette from a storage location that was for the wrong patient. In 2 additional cases, an epoprostenol cassette was accidentally switched for treprostinil, or vice versa, with patients receiving the wrong medication. Symptoms resulting from both types of errors ranged from no symptoms to nausea, flushing, lightheadedness, syncope and, in 1 case, death. The fatal event occurred when a patient on a moderate dose of epoprostenol received an epoprostenol cassette intended for another patient and was overdosed (4× concentration). The patient developed nausea and hypotension followed by pulseless electrical activity arrest.

Institutions that transitioned patients to hospital pumps also had serious errors. These included the wrong rate being programmed in the pump, errors in dose calculations, and episodes in which the dedicated prostacyclin line was flushed, leading to a bolus of prostacyclin. Two errors involved very high doses of prostacyclin administered over a short time period, with both cases leading to severe hypotension and cardiopulmonary arrest. In the first instance, a near-fatal hypotensive event occurred when a nurse flushed undiluted treprostinil through the in-dwelling line. In this case the patient was resuscitated with CPR. In the second case, a patient died after a nurse pro-