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TECHNICAL REPORT

How we do it: shifting MR arthrogram compounding from the fluoroscopy suite to the sterile pharmacy

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Abstract

Objective To assess the impact of shifting arthrogram injectate compounding from the fluoroscopy suite to the main hospital sterile pharmacy on cost, examination delays, and infection rates.

Materials and Methods All arthrograms from the 12 months before (629 in total) and the 12 months after (699 in total) the change in arthrogram preparation procedure were compared to identify differences in examination delays and infection rate. The arthrogram formulation was sent to the Compounder's International Analytical Laboratory for stability testing. Finally, cost per injection analysis was performed to compare fluoroscopy suite with sterile pharmacy compounding.

Results In the 699 arthrograms performed in the 12 months following transfer of arthrogram preparation to the main hospital pharmacy, there were 0 reported examination delays, 0 reported infections, and a 53% decrease in the material cost per arthrogram. There were three recorded instances of fluoroscopy suite preparation of arthrogram injectate due to unexpected add-on patients. Outside stability testing determined that the arthrogram injectate retained at least 90% potency 30 h post-preparation.

Conclusion Shifting the compounding of the arthrogram injectate from the fluoroscopy room to the main hospital sterile pharmacy provides a modest cost saving and can be accomplished without examination delays or any increase in infection rate. It brought our practice into compliance with USP797, which is the current guideline for compounding practitioners, by transferring the compounding preparation of the arthrogram injectate from a procedure room to the sterile pharmacy.

Introduction

Intra-articular injection of gadolinium-containing contrast medium before MRI is a common and safe procedure. In a survey of 57 radiologists representing 126,000 arthrograms, there were only 3 cases of infection [1]. A more recent prospective study of 1,085 patients undergoing MR arthrography showed no infections or other severe side effects [2]. There is a risk of infection, albeit low. This was exemplified by a case series of three arthrogram-related infections over a 14-month period in a Detroit hospital, with two of the infections happening within 10 days of one another. Institutional review determined that this was likely due to contamination from barium GI studies performed in the same room [3]. In these infections, the arthrogram procedure involved compounding of the injectate in the fluoroscopy suite.

At our institution, which operates a radiology residency, the traditional practice was to have a radiology resident compound the injectate in the fluoroscopy suite over a sterile field, which was a violation of USP797, the current guideline for compounding practitioners. The compounding is usually performed by a PGY-2 level resident on the musculoskeletal service, but residents of all PGY levels and staff physicians also compound when the PGY-2 resident is unavailable. This in-room preparation presents two problems. The first is that the resident may mistakenly draw incorrect volumes or omit a component of the injectate. The second is that the fluoroscopy suite is not routinely terminally cleaned between patients and may be a source of infection. A contributing factor to this issue at our institution is that we are an Army training center for radiology technologists. This occasionally presents the situation where an inexperienced technologist is assisting a junior resident. The compounding of the injectate in the hospital's

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main sterile pharmacy significantly simplifies the in-room procedure, as it eliminates the relatively complex compounding interaction between technologist and resident.

The above problems and our desire to comply with the most recent USP797 [4] guidelines for compounding practitioners spurred our initiative to shift the compounding of injectate to the hospital's main sterile pharmacy. This shift has four potential benefits. The first is that the injectate is compounded in a sterile hood rather than in the open environment of the fluoroscopy suite. The second is that the injectate is being prepared by a professional within their usual scope of practice. The third is that by removing the compounding process from the arthrogram appointment block, less time should be required per arthrogram. The fourth is a decrease in cost per injectate due to the ability to re-use Magnevist vials under a sterile hood. The purpose of this study is to evaluate the success of this shift as it pertains to cost, examination delays, and infection rate.

Materials and methods

The traditional method of in-room fluoroscopy compounding at our institution consists of the following: at the time of arthrogram administration, 0.1 mL of Magnevist is drawn from a 5 mL vial and added to a 20 mL syringe containing 10 mL 0.1% lidocaine from a single-use 20-mL vial, and 10 mL Isovue 200 from a single-use 10-mL vial. The remainder of the 5-mL Magnevist vial and 20-mL lidocaine vials are discarded. Costs are as follows: $0.79 per 20 mL lidocaine of which 10 mL is consumed per arthrogram, $6.90 per 5-mL Magnevist vial of which 0.1 mL is used per arthrogram, $4.73 per 10-mL Isovue 200 vial of which one vial is consumed per arthrogram. This results in a total cost of $12.42 per injectate.

The new method of pharmacy compounding consists of the following. In the morning on the day of administration, 0.1 mL of Magnevist is drawn from a 5-mL vial and combined with 10 mL of Isovue 200 from a single-use 10-mL vial and 10 mL of 1% lidocaine from a 20-mL vial. As the preparation takes place within a sterile hood, the remainder of the 5-mL Magnevist vial and the 20-mL lidocaine vial are re-used for compounding subsequent injectate. The pharmacist then seals the end of the syringe. Once all of the day's injections are prepared, the syringes are sent to the head fluoroscopy technologist who is responsible for setting up the fluoroscopy suite before injections are carried out. Costs are as follows: $0.79 per 20 mL lidocaine of which 10 mL is consumed per arthrogram ($0.39 per arthrogram), $6.90 per 5-mL Magnevist vial of which 0.1 mL is used per arthrogram ($0.14 per arthrogram), $4.73 per 10-mL Isovue 200 vial of which one vial is consumed per arthrogram. This results in a total cost of $5.26 per injectate.

The $5.26 figure represents the theoretical minimum cost, but this varies depending on how many arthrograms are performed during the day, as the remainder of the Magnevist vial will be wasted at the end of the day. At our institution, 10 arthrograms are performed per day. This means our actual cost per injectate is $5.81. The $0.55 cent increase in price per injectate is due to the cost of Magnevist increasing to $0.69 per injection with only 10 arthrograms being performed.

To ensure stability of the compounded injectate, the arthrogram mixture was sent for stability testing at the Compounder's International Analytical Laboratory. Note that the mixture sent for stability testing included 0.2 mL of Magnevist, but the final approved injectate contains only 0.1 mL Magnevist. This was done because 0.1 mL Magnevist is a more commonly used injectate concentration and has the benefit of using less gadolinium. Our facility's nuclear pharmacist was consulted and it was agreed that this change was not likely to affect the applicability of the stability testing.

Monitoring for arthrogram-related infection was performed in conjunction with the infection control department. The infection control department at our institution investigates all positive cultures reported in our electronic health record. As part of each investigation, the patient's chart is reviewed for any recent iatrogenic event, to include arthrogram injection. At the conclusion of the 24 months of our data collection, infection control reported that no positive cultures were associated temporally with an arthrogram.

Finally, to assess the impact of in-pharmacy compounding, the process was observed for 12 months as part of continuing quality improvement to assess for any examination delays and to quantify the number of add-on arthrograms requiring in-room preparation. All arthrograms performed at our institution were included for analysis.

Results

A total of 699 arthrograms were performed over 12 months following the switch to compounding in the hospital's main sterile pharmacy compared with 629 arthrograms performed in the preceding 12 months. In the 12 months following the switch, there were 0 examination delays and 0 arthrogram-related infections. There were three instances of needing to compound the injectate in the fluoroscopy suite owing to unforeseen add-on procedures performed for military-related urgency. Each of these three arthrograms was compounded by a radiology resident in the fluoroscopy suite without issue.

Cost analysis reveals a significant reduction in per-dose cost to $5.81 when compounding in the hospital's main sterile

Table 1 Arthrogram injectate stability testing results

Tracking designation	Active ingredient(s)	Concentration(s) (mg/ml)	Concentration found (mg/ml)	Potency (%)	Comments
Start time	Gadopentetate dimeglumine	4.634	4.65	100.4	All APIs meet expected potencies. This establishes the baseline for the stability study
	Lidocaine, HCl	4.95	5.09	102.9	
	Iopamidol	201.98	201.76	99.9	
After 30 h	Gadopentetate dimeglumine	4.634	4.18	90.2	Lidocaine has maintained potency after 30 h. Gadopentetate has declined 10%, and iopamidol has declined 7%. There were no visible indications of incompatibility. The mixed solution remained clear even after 48 h
	Lidocaine, HCl	4.95	5.08	102.6	
	Iopamidol	201.98	187.83	93.0	

API active pharmaceutical ingredient

pharmacy versus a per dose cost of $12.42 when compounding in the fluoroscopy suite, a 53% decrease.

Stability testing was performed on the mixture of 0.2 mL Magnevist, 10 mL 1% lidocaine, and 10 mL of Isovue 200, revealing greater than 90% retained potency of all components after 30 h. Potency is defined by the laboratory as the percentage concentration remaining of each active pharmaceutical ingredient. These results are presented in Table 1.

Discussion

Magnetic resonance arthrography (MRA) has now been in use for over 25 years [5]. MRA has been shown to improve the sensitivity and specificity of shoulder MRI when evaluating for partial-thickness rotator cuff tears and when detecting unstable labral tears [6–8]. Intra-articular infection rates are reported to be extremely rare, at 0.00002% in a survey of 126,000 arthrograms [9] and 0% in a prospective study of 1,085 patients [2]. This is in accordance with our data at our institution. There were 0 reported infections associated with the 1,328 arthrograms performed in the 24-month observation period assessing the shift to compounding injectate in the hospital's main sterile pharmacy.

In preparation for the switch to pharmacy compounding, concerns regarding the stability of the injectate mixture needed to be addressed. The Compounder's International Analytical Laboratory in Castle Rock, CO, USA, was contracted to perform stability testing for our specific planned mixture of 0.2 mL Magnevist, 10 mL 1% lidocaine, and 10 mL Isovue 200. The results showed 90% potency of the Magnevist, 93% potency of the Isovue, and 100% potency of the 1% lidocaine at 30 h. The extension of the stability test to the 30-h mark served to give the hospital's main sterile pharmacy a wide range of workflow options so that the arthrogram injectate could be compounded in off-peak hours without concern for degradation. This supplements previous stability testing that showed no significant gadolinium ion dissociation from gadopentetate at 24 h, even after adding iodinated contrast medium, saline, lidocaine or epinephrine [10]. The addition of lidocaine to the injectate is helpful as it allows the patient to have a more comfortable examination during the MRI and enables the physician to evaluate pre- and post-procedure pain scales to assess for an intra-articular source of pain.

Our institution performs approximately 700 arthrograms annually. The primary end point of this study is to assess the impact of this procedural change on cost, examination delays, and infection rate. A secondary endpoint is bringing our institution into compliance with USP797, which is the guideline for compounding pharmacists produced by the United States Pharmacopeial Convention. Over the course of the 12 months following the change, there were no examination delays due to the preparation of injectate in the sterile pharmacy. Additionally, although data were not specifically collected, physician feedback reveals that this change resulted in decreased time spent performing each arthrogram as there is no longer in-room compounding at the time of the procedure. Further efforts to quantify this change and assessment of adjusting appointment times is being considered for future investigation at our institution.

The shifting of injectate compounding from the fluoroscopy suite to the hospital's main sterile pharmacy resulted in a 53% decrease in material cost per arthrogram, as detailed in the Materials and methods section. The percentage decrease in cost varies depending how many arthrograms are performed each day, because of the wastage of unused Magnevist at the end of each day. The theoretical maximum decrease in cost is 58%. This decrease in material cost was primarily due to the ability to re-access multi-use vials. The capability to re-access these vials is caused by the presence of a sterile compounding hood in the sterile pharmacy. This cost analysis is limited by the inability of this study to compare the more abstract costs of the pharmacist's time versus the physician's time spent

performing the compounding. Additionally, there were three instances that required compounding injectate in the fluoroscopy room after the shift due to add-on patients. These add-on patients were same-day additions because of urgency for military readiness and are less likely to be a factor in a civilian practice. The same-day add-on patients do provide a possible source of increased chance for error as the compounding resident and technologist are likely to be significantly less experienced or experience skill atrophy in the future owing to the bulk of the compounding being shifted to the pharmacy at our institution. Specifically, at the rate of three instances per year, it is likely that each resident will compound only one injectate in a 4-year program.

Monitoring for arthrogram-related infections was accomplished in conjunction with our infection control department. The infection control department at our institution investigates all positive cultures reported in our electronic health record. As part of each investigation, the patient's chart is reviewed for any recent iatrogenic event, to include arthrogram injection. At the conclusion of the 24 months of our data collection, infection control reported that no positive cultures were associated temporally with an arthrogram.

In conclusion, shifting the compounding of the arthrogram injectate from the fluoroscopy room to the hospital's main sterile pharmacy results in a modest cost savings and can be accomplished without causing examination delays or increasing the infection rate. The shift also brought our practice into compliance with USP797 by transferring the compounding preparation of the arthrogram injectate from a procedure room to the sterile pharmacy.

Compliance with ethical standards

Disclaimers None.

Sources of support None.

Conflicts of interest None.

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