

# Quality improvement measures for early detection of severe intravenous infiltration in infants

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## ABSTRACT

Intravenous infiltration is one of the most commonly seen morbidity in infants admitted to the neonatal intensive care unit (NICU). The risk of intravenous infiltration in preterm infants is probably due to prolonged peripheral intravenous access requirement for nutritional support and usage of other intravenous medications to support their growth. Infants are more likely to develop intravenous infiltrations due to the increased fragility of their blood vessels, deficient subcutaneous tissue and inability to express pain. As a result, the intravenous infiltrates in infants can rapidly progress to severe stage 3 and stage 4 infiltrates with necrosis if timely intervention is not provided. Also, factors obscuring to identify stage 1 and stage 2 infiltrates, may lead their progression to severe infiltration. Root cause analysis was performed following two severe intravenous infiltrates that required plastic surgery intervention in our level III NICU. Quality improvement measures were implemented. We developed a unique intravenous securing method, conducted educational programmes for NICU staff, increased intravenous site surveillance and ascertained to maintain the intravenous pump pressures in the reference range. The hospital NICU intravenous care policy was updated with quality improvement measures. Data were collected preintervention and postintervention. The incidence of intravenous infiltration in preterm infants varies widely in different places. This may be due to under-reporting of these relatively rare adverse events, but may also be due to the fact that the preterm infants represent a small portion of the patient population. The present study has shown that severe infiltration was associated with an increase in intravenous days. Following the quality improvement measures, there were no reported cases of severe intravenous infiltration. In conclusion, the awareness of the problem with evidence-based quality improvement measures may help in early detection of intravenous infiltrates and decrease the severe intravenous infiltration in infants.

## PROBLEM

We are a small community hospital in Pennsylvania, USA with an average of about 1200 deliveries per year. Our neonatal intensive care unit (NICU) is a level III NICU with eight beds, and an average census of 125 admissions per year. There were two stage 3 to stage 4 infiltrates reported in September and October of 2015. Based on the severity of the lesions, root cause analysis was performed

to assess quality measures and patient safety checks. After an extensive review of these two incident reports by quality assessment team members, possible risk factors were identified. The summary of the root cause analysis is stated below in the following three paragraphs.

In both these cases, infants were preterm, less than 34 weeks gestation, required peripheral intravenous access for greater than 4 days. One of them was on intravenous antibiotics for presumed sepsis, and another infant was on parenteral nutrition for a longer period of time due to feeding intolerance. In these two cases, subcutaneous injections of Hyaluronidase were used to treat significant intravenous infiltration. It was also identified from the nurses and physicians documentation that routine measures like warm compresses and elevation of the infiltration site were used to lessen the severity of the infiltration injury. Despite these measures, the intravenous infiltrates in these infants progressed to stage 3 to stage 4 infiltrates. Plastic surgery consultation was also obtained due to the severity of the injury and care was rendered per their recommendation. Fortunately, both cases have healed without any secondary complications.

The risk analysis report included a review of the NICU intravenous care protocol. According to the unit protocol, if an infant is clinically stable, intravenous site assessments by nurses can be performed every 4 hours. It is also required to document their patient's intravenous site assessment in the flow sheet every 4 hours. The root cause analysis report showed infrequent intravenous site documentation by nurses in their flow sheets. In these two cases, documentation of intravenous assessments by nurses in the flow sheets was randomly listed in varying intervals, greater than 4 hours in their notes. Hence, it was unclear if the intravenous site assessments were performed every 4 hours due to lack of documentation.



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Moreover, despite significant infiltration in these two cases, the Alaris intravenous pumps that were used in our NICU have failed to show pressure alert. Our report also showed that annual quality check and maintenance of NICU intravenous pumps were performed as per hospital unit policy by the biotechnical department. Intravenous pump quality assessment cards that are attached to the pumps show the details of the assessment and the day it was completed. We have also collected intravenous pump pressures from biotech personnel and identified that the pump pressures were maintained in the manufacturers given range.

## BACKGROUND

Intravenous (intravenous) infiltration due to extravasation is one of the most common unintentional adverse events seen in infants admitted to NICUs. Accidental infiltration into loose connective tissue can cause significant morbidity.<sup>1 2</sup> Infants, particularly premature babies, are at increased risk due to special requirements to support their growth with hyperosmolar parenteral solutions and lipid infusions. Also, the usage of certain medications like dopamine or epinephrine in critically ill babies can cause extensive damage from the extravasation injuries sometimes losing an extremity of the infant.<sup>3-5</sup> Previous studies have shown the incidence of intravenous infiltrations as high as 70% in infants. Studies have also shown that these results vary widely in different places and this may be due to under-reporting of these adverse events. Among these infiltrates, it has been estimated about 4% required cosmetic intervention, either due to scar formation or other anatomical or functional impairments.<sup>6 7</sup> Evidence shows that preterm infants are more prone to significant damage from intravenous infiltration due to the increased fragility of their blood vessels and lack of subcutaneous tissue. Also, lack of their ability to express pain is another factor that adds to the difficulty in identifying



**Figure 1** Sangam's intravenous securing method: Peripheral intravenous site secured with transparent tegaderm over the catheter and no opaque tape applied along its entire intraluminal portion.

stage 1 and stage 2 infiltrates. These factors lead to the rapid progression of early stage 1 and stage 2 infiltrates to more severe forms stage 3 and stage 4 infiltrates with necrosis if timely intervention is not provided.<sup>8 9</sup>

Management of infiltration is commonly performed by limb elevation after removal of the catheter. Multiple punctures technique is used to remove the toxic extravasated fluid and relieve the pain from significant swelling. Antidotes like phentolamine and nitroglycerine are commonly used for extravasation of vasoconstrictors. Hyaluronidase is an enzyme which is commonly used to treat intravenous infiltration in many NICUs. It is known to dilute the toxic effects of infusate by diffusing into a wider surrounding area by breaking the connective tissue substance.<sup>3</sup> British National Formulary does not recommend its routine use in infants due to lack of evidence in this population.<sup>10</sup> Developing ongoing quality improvement strategies to prevent the morbidity from significant intravenous infiltration is the best means to protect this vulnerable group of patients.

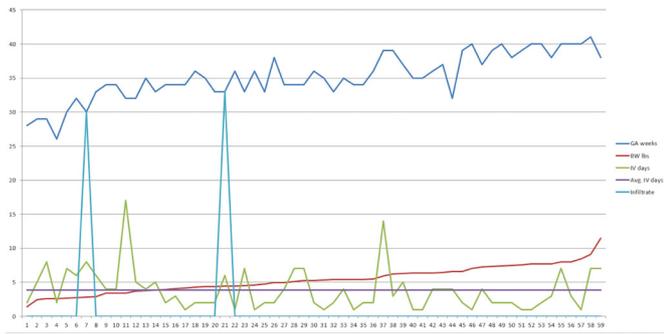
## SPECIFIC AIM

We had two severe infiltrates in our NICU. Our primary aim was to develop quality improvement measures to decrease severe intravenous infiltration in infants admitted to NICU by 50% in 6 months. After extensive root cause analysis of two severe intravenous infiltrates, we have identified certain evidence-based measures that may help identify the intravenous infiltration in early stages and decrease the severe infiltrations. We have made frequent intravenous site assessments and documentation mandatory. We developed a unique intravenous securing method to help us identify the early signs of intravenous infiltrates. We have also conducted educational sessions to the NICU staff, nurses and physicians. Intravenous pump pressures were maintained in mid reference range avoiding the lower and higher normal range.

## METHODS AND INTERVENTION

Based on the data obtained from two identified stage 3 to stage 4 intravenous infiltrates in the September and October 2015, possible risk factors were identified. Strategies to improve early detection of intravenous infiltration were studied and quality improvement measures are implemented. NICU intravenous care protocol was updated in November 2015. Intravenous site assessments were performed every hour and documentation of the assessments was made mandatory by obtaining initials of the nurse taking care of the patient in the flow sheets.

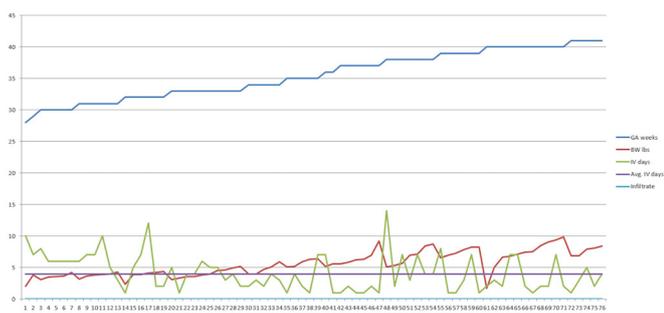
One of the main factors that cause severe infiltration is failure to recognise them in the initial stages. We have identified that less occlusive dressing on the catheter can provide better visualisation of the intravenous site. We developed a unique intravenous securing method, Sangam's method. Intravenous catheter from the site of insertion into the lumen of a vein to its entire length above the site of insertion is covered only with a transparent



**Figure 2** Preintervention: X-axis represents 59 patients in the preintervention group. Y-axis is scaled from 0 to 45. The dark blue curve represents the infant's gestational age in weeks, the red line represents birth weight in pounds and the green wavy line represents the total number of intravenous days. The two long spikes in light blue represent the two severe infiltrates. These two babies required intravenous lines for greater than the mean intravenous days, which is equal to 4 days, shown in the picture as a purple line. The picture also shows that these babies were less than 5 pounds and <34 weeks gestational age. This picture is developed using Microsoft Excel.

tegaderm as shown in figure 1, which is demonstrated on an infant manikin. By securing the catheter site with a transparent material, we were able to identify the early signs of infiltrate, which are erythema, tenderness and induration or redness, pain and swelling respectively. Any of the above stated signs were identified as an initial stage of infiltration and the intravenous catheter was removed.

Educational sessions to demonstrate the tapping technique were conducted by NICU nurse educator and advanced neonatal nurse practitioner. Nurses and physicians were trained to demonstrate the newly developed intravenous securing method using an infant manikin and the actual tapping materials. Since we were a small level III NICU, to maintain 100% adherence was maintained without difficulty.



**Figure 3** Postintervention: X-axis represents 76 patients in postintervention group. Y-axis is scaled from 0 to 45. The dark blue curve represents the infant's gestational age in weeks, the red line represents birth weight in pounds and the green wavy line represents the total number of intravenous days. No infiltrates are seen in the postintervention group. Also, the mean intravenous days in this group as shown in the picture as a purple line is also equal to 4, which is similar to the preintervention group. This picture is developed using Microsoft Excel.

Biotechnical personnel support was also obtained to ensure the quality improvement measures. As mentioned earlier, despite significant infiltrates, the Alaris intravenous pumps that were used in our NICU, failed to show pressure alert. The intravenous infiltration may have spread very rapidly and extensively without causing significant pressure changes probably due to very loose and fragile connective tissue in infants. And this may possibly explain the lack of pressure alert in these two cases. We maintained the intravenous pump pressures in the manufacturer given range and their annual maintenance assessments per hospital policy.

### Frontline members

Frontline people are the nurses in the unit. Educational programme on securing methods, strategies to recognise infiltrates in early stages, performing patient safety checks every hour and documenting in the flow sheet are among the main interventions.

### RESULTS

Data were collected preintervention and postintervention. Data from January 2015 to October 2015 were collected retrospectively. Incident reports of infants who developed severe stage 3 to stage 4 intravenous infiltrates admitted to NICU were collected. This period includes the two severe incident reports of infants who developed severe stage 3 and stage 4 infiltrates admitted to NICU. Collection of data by chart review was performed in addition to incident reports of severe intravenous infiltrates. The electronic query for use of Hyaluronidase in infants admitted to NICU was collected to inquire for severe infiltrates.

Postintervention data were collected prospectively from November 2015 to October 2016 after the quality improvement measures were implemented. The specific aim of the study was to decrease the intravenous infiltration rate in babies admitted to NICU by 50% in 6 months. However, we have not encountered another severe intravenous infiltrate in the first 6 months of the postintervention period. It was not clear whether the interventions caused good outcomes or if it was due to a short period of time. Moreover, the severe infiltrates are rare events; hence the data collection was continued prospectively for a total of 12 months in the postintervention period to have an adequate sample size.

Data is plotted using Microsoft Excel. The total number of patients is shown on the x-axis and gestational age, birth weight, intravenous days are scaled from 0 to 45 on the y-axis as shown in figures 2 and 3.

### DISCUSSION

Intravenous infiltration is clinically identified as four stages based on the severity of the lesion. Stage 1 and stage 2 present with mild pain, erythema and swelling, stage 3

with significant pain, swelling, blanching and stage 4 as decreased capillary refill, decreased pulses and necrotic skin.<sup>11</sup> Many studies have shown various quality improvement strategies to improve the early detection of intravenous infiltrates. In previous studies, infrequent assessment and lack of documentation have shown to increase the incidence of severe infiltrates. One such study shows that the frequent intravenous assessments have identified the infiltrates in early stages and have shown to decrease the incidence of severe stage 3 and stage 4 infiltrates.<sup>12</sup> Also, a quality improvement study by Cincinnati Children's Hospital Medical Center has developed touch-look-compare method for hourly intravenous site assessments. This study has observed a significant reduction in their intravenous infiltration rate, but their effect has not been sustained.<sup>13</sup>

The data in our preintervention and postintervention groups were analysed. There were a total of 59 patients in the preintervention group and the postintervention group included 76 patients, which is more than the preintervention group. The average intravenous days in preintervention and postintervention groups were calculated by adding the total number of intravenous days in each group and dividing that number with the total number of patients in that group respectively. The average number of intravenous days in the preintervention group was 3.9 days and in the postintervention group were 4.1. The average number of intravenous days, represented, as a purple line in preintervention and postintervention groups is about 4 days, almost similar in the two groups, though a little more in the postintervention group, as shown in [figures 2 and 3](#). In the preintervention group, the two long spikes in light blue colour represent the severe infiltrates. These two incidents were in patients with a lower birth weight and <33 weeks gestational age who required greater than the average number of intravenous days which is greater than 4 days as shown in [figure 2](#). Our study supports the existing evidence that low birth weight and lower gestational age infants are at increased risk for severe intravenous infiltration.

Following the quality improvement measures, namely, Sangam's intravenous securing method, educational programmes, hourly intravenous checks in flow charts and maintaining intravenous pump pressures in the reference range, the severe intravenous infiltration events have decreased significantly. To this day, we have not encountered a severe intravenous infiltration requiring intervention. Despite these promising results, the study cannot conclusively state that the decrease in these events is by chance or an outcome of these interventions. This is because the study lacks the data collection for identification of early infiltrates in the postintervention phase. However, this study supports prior studies that have reported the increased incidence of intravenous infiltrates in low birth weight, lower gestational age and in infants who require prolonged intravenous lines. We have developed a unique Sangam's intravenous securing method, which may identify the intravenous infiltrates in early stage, thereby preventing their progression to

severe stage 3 to stage 4 infiltrates in this vulnerable patient population.

Initiatives implemented for the sustainability of the quality improvement measures were as follows: Educational sessions were made mandatory to the NICU nursing staff. NICU new hires, as well as temporary travel nurses, were trained with the newly developed intravenous securing method on an infant manikin. To obtain 100% adherence to the quality improvement measures, NICU intravenous protocol was updated. The developed intravenous securing method, frequent intravenous site assessments and documentation were made mandatory. Intravenous pump assessments were monitored per unit policy.

### Lessons learnt

The study shows severe intravenous infiltration increases with an increased number of intravenous days. Another finding identified in this study that was also supported by previous studies was higher incidence of severe infiltrates in lower gestational age and lower birth weight infants. The fact that the smaller the infant, the higher is the risk of severe intravenous infiltration is due to many factors like their small size of blood vessels, less subcutaneous tissue and inability to express their pain. Using transparent tape over the entire intraluminal portion of the intravenous catheter may have shown to identify the early signs of intravenous infiltration and prevent its progression to severe stage 3 and stage 4 infiltration. Also, the study supports the existing evidence that frequent intravenous site assessments and documentation may assist in identifying the intravenous infiltration in early stages, thereby preventing their progression to the severe stages.

### Limitations

The challenges faced by the team were resistance from nurses to perform frequent assessments and documentation. To address this problem and to attain adherence to the quality improvement measures, the intravenous site assessments and documentation were made mandatory every hour by nursing initials in flow sheets and the intravenous protocol was updated with these quality improvement measures. Though the NICU nurses were given a demonstration of the unique securing method using a manikin and educational presentations on identifying early signs of intravenous infiltration, change in knowledge assessments was not followed after these educational sessions. Sometimes, difficulties in identifying the early signs of intravenous infiltration particularly by less experienced nurses are not uncommonly seen.

NICU at our hospital is a level III, small to medium size unit. The unique and uniform taping method used in this study to secure the intravenous site may be quite challenging to obtain similar results in bigger units. Also in smaller NICUs which may have few per diem and travel nurses, continued educational programme and updates on policies are relatively easy compared with bigger units. It may be difficult to provide the educational programmes to temporary nursing staff in larger NICUs. They may

not receive the ongoing educational updates and quality improvement training.

A major limitation of the study is its small sample size. Besides, the frequency of these rare events in a small unit is not sufficient to study as a measure. Hence, the study cannot conclusively determine whether the absence of the severe intravenous infiltration is the outcome of interventions or by chance due to the rarity of these events with a small sample size. Also, measuring the preintervention and postintervention is not the best strategy to study the rare events like severe intravenous infiltration.

### Summary and conclusion

Following the quality improvement measures, there were no further case reports of severe intravenous infiltrates in our NICU. Awareness of the problem and continued evidence-based approaches may decrease significant morbidity from severe intravenous infiltration in neonates.

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**Competing interests** None declared.

**Patient consent for publication** Not required.

**IRB approval** The changes in intravenous protocol were implemented as quality improvement measures and mandated through NICU intravenous care policy following two severe intravenous infiltrations. IRB review was not obtained prior to implementing policy changes as this study met the criteria for exemption from such review according to the institutional policy.

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