The safer use of intravenous gentamicin for neonates

Gentamicin is an aminoglycoside antibiotic with broad spectrum bactericidal activity used in 89% of neonatal units in England for the treatment of neonatal infection. During the year 2008-2009, fifteen per cent of all reported neonatal medication patient safety incidents related to its prescription and administration. The National Patient Safety Agency (NPSA) has produced a Patient Safety Alert which aims to improve the safety of gentamicin use for this group of patients. The Alert incorporates the use of a care bundle, implementation using improvement methodology and the provision of training for all staff involved in its use.

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Key points

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- 1. A care bundle has been developed for the administration of iv gentamicin to neonates.
- Key elements include using the 24 hour clock, ensuring no interruptions during administration, using a double checking prompt and giving the prescribed dose within one hour of the prescribed time.
- The care bundle should be implemented by using improvement methodology and compliance should be measured daily for each patient.

n February 2010 the National Patient Safety Agency (NPSA) released a Patient Safety Alert on 'The Safer Use of intravenous Gentamicin for Neonates'¹ to address a number of patient safety issues related to this medication.

Gentamicin is a broad spectrum aminoglycoside antibiotic that is widely used in the treatment of neonatal infection. A survey of 180 neonatal units in England carried out in 2007 indicated that 89% were using intravenous gentamicin.

The NPSA captures patient safety incidents via its National Reporting and Learning System (NRLS). From 1 April 2008 to 31 March 2009 507 incidents, 15% of all neonatal medication incidents reported, were related to the administration of intravenous gentamicin to neonates. Analysis of these incidents highlighted that:

- 36% of cases related to the administration of gentamicin at the incorrect time
- 24% of cases were attributed to a prescribing error
- 17% of cases were related to gentamicin blood level monitoring
- 96% of incidents resulted in no or low harm while 4% (n=23) were reported as resulting in moderate harm. These figures do not take into account harm which may manifest following discharge.

The NPSA working with the Royal College of Paediatrics and Child Health, the Royal College of Nursing, the Neonatal Nurses Association, the British Association of Perinatal Medicine and Bliss developed a care bundle to improve the safety of gentamicin use. The Alert issued this February applies to all NHS organisations that provide neonatal services. The key action points of the Alert are:

1. A local neonatal gentamicin policy is available that clarifies the initial dose and frequency of administration, blood level requirements and arrangements for subsequent dosing adjustments based on these blood levels.

2. Local policies and procedures are developed or revised to state that intravenous gentamicin should be administered to neonates using a care bundle incorporating the following four elements:

- When prescribing gentamicin the 24hour clock format should be used and unused time slots in the prescription administration record should be blocked out to prevent wrong time dosing.
- Interruptions during the preparation and administration of gentamicin should be minimised by the wearing of a coloured apron by staff.
- A double-checking prompt should be used during the preparation and administration of gentamicin (provided with the Alert, see **FIGURE 1**).
- The prescribed dose of gentamicin should be given within an hour either side of the prescribed time.

3. Neonatal units implement the care bundle using improvement methodology and small cycles of change, such as Plan Do Study Act (PDSA) Cycle, with a sample group of patients.

4. Compliance with the care bundle is measured daily for each patient in the

Blood level monitoring: Any actions required in the section below should be prioritised to ensure doses are not delayed:		
1.	Check the date and time of the next blood level required. Are any blood levels required prior to, or post administration?	
2.	Do any blood level results need action prior to administration of this dose? ie results chasing or results interpreted.	
3.	If yes to question two, has the person responsible for the interpretation of result been informed?	
4.	Has the blood level result been interpreted correctly? If not escalate as per local policy.	
5.	Does the dose or dosing interval need changing as a result of the blood level result? If yes ensure this is actioned as per local policy.	
Pre	scription chart details:	
6.	Check the time recorded when dose last given and the frequency prescribed. Is a dose due now?	
7.	Is the patient's current weight recorded on the prescription chart correct? <i>Caution: Ensure the weight is recent and realistic.</i>	
8.	Has the correct dose been prescribed based on the weight? Each checker to calculate the dose separately.	
9.	Is the dosing regimen and frequency correct for gestational age? Check against local neonatal gentamicin policy. <i>Caution: Any deviation from approved</i> <i>prescribing practices should be escalated as per local policy.</i>	
10.	. Has the prescription been signed by the prescriber?	
Via	l or CIVAS details:	
11.	. Is this the correct medication?	
12.	. Is this the correct strength of gentamicin, ie 20mg/2mL? (N/A for CIVAS)	
13.	Has the correct volume been drawn up? Each checker to calculate dose separately.	
Ad	ministration:	
14.	Does the patient's identity match the patient details on the prescription chart?	
15.	. Has the prescription chart been signed by the administrator with details of the time of administration?	

FIGURE 1 Double checking prompt for the preparation and administration of intravenous gentamicin.

sample group until full compliance for all patients receiving gentamicin is achieved.

5. All staff involved in the prescription and administration of intravenous gentamicin are provided with training relating to its use. This should include education regarding the interpretation and management of gentamicin blood levels, including action to be taken in relation to dose or frequency following a blood level result.

The actions within this Alert should be completed within one year, by February 2011. Compliance with the Alert will be monitored through the Central Alerting System (CAS).

Risks associated with gentamicin

In addition to the high number of patient safety incidents reported relating to the prescription, administration and blood level monitoring of gentamicin, it is also associated with a risk of adverse effects,

specifically hearing impairment and renal damage. Adverse effects are particularly associated with patients with pre-existing poor renal function, where a longer duration of therapy has been used, and where gentamicin blood levels have been elevated above the accepted range for a period of time². Most of the data on gentamicin toxicity relates to studies carried out in adults; evidence in neonates is limited. The potential risk of ototoxicity and nephrotoxicity requires administration of gentamicin within an accurate timing regime and close monitoring of blood levels to keep gentamicin concentrations within the accepted therapeutic range.

Serum levels of gentamicin can be monitored through the measurement of both peak and trough gentamicin blood levels. A peak level is the amount of drug that is in the blood shortly after administration. Peak levels correlate with the drug's efficacy, as the rate and extent to which an aminoglycoside achieves its effect is a function of its concentration. The trough blood level of a drug is the amount of drug that is in the blood just before the next dose is due. Trough levels reflect renal clearance. If the kidney is unable to excrete the dose of aminoglycoside within the dosing interval, nephrotoxicity³ may occur. Impaired renal function will affect the ability of the kidney to excrete aminoglycosides. High trough blood levels of gentamicin have also been associated with hearing loss⁴. Hearing loss in neonates may not be detected while they are on the neonatal unit and therefore evidence of harm due to gentamicin or any other cause may not be apparent until some time after discharge.

Prolonging the time interval between doses of gentamicin has been advocated to provide more time for clearance of gentamicin, resulting in less accumulation, and lower trough levels which can minimise toxicity.5 The British National Formulary for Children currently details five dosing regimens for the administration of gentamicin for neonates which account for gestational age. Two of these are extended interval dose regimens and three are multiple daily dose regimens. As a result of this guidance, dosing regimens vary across neonatal units and there is corresponding variation in blood level monitoring arrangements.

The care bundle approach

A care bundle approach was chosen by the expert working group as a method by which the risks associated with the administration of gentamicin could be reduced. A care bundle is a 'structured way of improving processes of care and patient outcomes'6. It consists of a number of clinical interventions that every patient should receive collectively during one clinical episode of care. To measure whether the care bundle is being effectively applied, clinical teams using a bundle should record, on a continual basis, how many patients receive all elements of the bundle, with the aim of achieving 100 per cent compliance.

The care bundle approach to therapeutic interventions is advocated as one of the Institute of Innovation and Improvement's high impact changes as outlined in the report; 'Increasing the reliability of performing therapeutic interventions through a care bundle approach'⁷. In the

CARE BUNDLE





Cycle #1 Meeting # – date	Start date: End date:		
Objective of cycle			
Plan	Are all staff aware of the care bundle/receiving training?		
	Have we identified a 'champion'?		
Act Plan	Have we established an aim statement and operational definition?		
	Do we understand the measures we are using?		
Study Do	How many patients will be involved in this cycle?		
	Who will be responsible for completing the daily care bundle audit chart?		
	Have we collected baseline data?		
	Who will be responsible for analysing data?		
	How often will data be analysed?		
	Who will organise and chair the data review meeting?		
Do	Undertake a staff awareness/training programme.		
	 Order coloured aprons/laminate double checking prompts. 		
Act Plan	Ensure compliance charts and care bundle audit charts are available		
Study Do	Collect data.		
Study	Analyse the data at monthly data review meetings.		
Act Plan	Are there any issues arising that need to be addressed to improve compliancy with the care bundle?		
chu bu Du	What actions are required to address these issues?		
Study Do	What elements of the care bundle need addressing?		
Act	 Use your data to create run charts and annotate with any issues which may have affected your results. 		
Act Plan	Share your results with your staff and senior leaders.		
Chudu Do	Implement identified actions arising from your data analysis.		
Study Do	Then back to 'plan' and next cycle.		

FIGURE 3 Example of a Plan Do Study Act plan.

UK care bundles have been promoted and used by the Patient Safety First campaign in England and 1000 Lives Campaign in Wales. The perceived benefits are that care bundles encourage collaborative working and provide an impetus for regular updating of guidelines so that they are in keeping with current best evidence-based practice. They also act as a tool to support implementation of best practice.

Evidence to support the efficacy and

acceptability of the gentamicin care bundle elements were synthesised from multiple evidence sources including:

- data from the NPSA's National Reporting and Learning System
- root cause analyses of gentamicin incidents
- a national survey of neonatal units in England on the use of gentamicin
- evidence from published literature
- expert opinion from the working group.

Support for implementation

The NPSA Alert is accompanied by a supporting teaching pack in the form of a powerpoint presentation. These slides include information on gentamicin blood monitoring, carried out to prevent drug toxicity and ensure drug efficacy. The four key principles of gentamicin blood monitoring are highlighted in **FIGURE 2**.

In order to help neonatal units implement the care bundle the NPSA has issued an accompanying 'how to guide' which uses the 'Model for Improvement' methodology which has been successfully used by the Patient Safety First campaign in England (www.patientsafetyfirst.nhs.uk) and 1000 Lives Campaign in Wales (www.wales.nhs.uk).

The guide advocates eight key actions to get started on implementing the care bundle within a neonatal unit.

- Engage senior leadership support
- Engage clinicians/provide education and training
- Link your work to a system level organisation goal
- Ensure a multidisciplinary team approach
- Find a local champion
- Measure your progress
- Provide improvement knowledge
- Continue to report incidents and learn from them.

The Model for Improvement

The Patient Safety Alert advises neonatal units to implement the care bundle using small cycles of change with a sample group of patients. The how to guide suggests staff implement the bundle using one patient, learn from that case and then implement using three patients, again learn from these cases and progress to five patients. The rationale for this approach is that sustained improvement is achieved through small scale change, using small sample groups of patients. The suggested model for testing changes is the PDSA cycle (see **FIGURE 3**). The Model for Improvement⁸ provides a framework around which to structure improvement activity to ensure the best chance of success. The model is based on three key questions in conjunction with small scale testing using the PDSA cycle.

Question 1: What are we trying to achieve?

In order to answer this question it is important that neonatal units construct a clear aim statement that is agreed and understood by all staff involved in the prescription and administration of gentamicin. An example of an aim statement would be:

'We will achieve 100 per cent compliance with all elements of the gentamicin care bundle by August 2010.'

Question 2: How will we know that a change is an improvement?

Choose the right measures

In the case of the neonatal gentamicin care bundle the percentage of gentamicin doses compliant with all four elements of the care bundle is measured. This is facilitated by a care bundle compliancy chart which accompanies the Alert. In order to be fully compliant with the care bundle the staff member who is administrating gentamicin to the patient must be compliant with all four elements of the care bundle. Compliance with three elements for example would be recorded as non compliant. The principle of care bundle methodology is that the power of a care bundle is through the application of every element of the care bundle to every patient who meets the inclusion criteria every time they receive that intervention.

Collect data

A neonatal gentamicin care bundle compliancy chart is completed for each patient in the sample group. In addition a neonatal gentamicin care bundle daily audit is also completed for all patients in the sample group. This records how many doses of gentamicin have been given (the denominator) and how many were compliant with all four elements of the care bundle (the numerator).

Present data using run charts

Run charts are a powerful tool that can be used to demonstrate whether a change has really resulted in improvement, and whether it has been sustained. Data from the audit charts can be input onto a



FIGURE 4 Example of neonatal gentamicin care bundle compliance run chart.

measurement extranet via the Patient Safety First or 1000 Lives Campaigns websites allowing individual units to view their data as a run chart. **FIGURE 4** is an example of a compliancy run chart that can be created on the extranet.

Question 3: What changes can be made that will result in an improvement?

Review and analyse your data

At the end of the month, a multidisciplinary team should meet to review the run charts and audit information. They can then discuss what action needs to be taken in order to improve the implementation of the measure. Run charts can be shared with all members of staff involved in implementing the care bundle to inform them of progress and highlight issues which need to be addressed to improve compliance.

Staff training

One of the key actions of the Alert is that all staff involved in the prescription and administration of gentamicin should be provided with training in its use. This training should include education regarding the interpretation and management of gentamicin blood levels including action to be taken in relation to dose or frequency following a blood level result. The NPSA has provided a training pack in the form of a powerpoint presentation alongside this Alert. This covers the key actions of the Alert, improvement methodology and details of compliancy and audit charts, as well as the key principles of therapeutic drug monitoring.

Conclusion

A survey of neonatal units in England undertaken in 2007 by the NPSA highlighted that many were experiencing problems with the prescription and administration of gentamicin. There was also significant variation in practice in undertaking pre and/or post dose blood level monitoring and in assigning responsibility for obtaining the results of levels from the laboratory. These issues were again borne out by data from the NPSA's National Reporting and Learning System. The NPSA Alert on neonatal gentamicin provides a national care bundle approach to the prescription, administration and monitoring of gentamicin and aims to reduce error and improve the safety associated with its use.

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