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Evaluation of the Most Effective Method of Measuring Bilirubin Concentration in Neonates

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ABSTRACT

Objectives: The Aim of this project was to determine the correlation of two methods of measuring bilirubin concentration in neonates "the laboratory and blood gas analyser". The ultimate purpose was to find the accuracy and validity of the bilirubin measurements using blood gas machine analyser. This is to determine whether it can reliably guide timely clinical decision and whether it can replace the traditional laboratory test for determining bilirubin values.

Methods: An ethical approval has been obtained to undertake a retrospective quantitative research study at neonatal intensive care units. 228 paired bilirubin measurements from hospitalized neonates were available for analysis. Bilirubin measurements obtained from the laboratory were compared with the paired sample results from four gas machine analysers. We included patients tested at the same time by both laboratory and blood gas analyser. Unpaired patients tested by only one method were excluded from the study.

Results: The correlation scatter graph (Figure 1) shows incredible matching of the two methods of bilirubin testing. The R value of 0.978 demonstrates a very high correlation value between both tests and both methods agree on treatment decisions. There was little to zero correlation between the µmol/L differences between the two methods in particular when phototherapy treatment is indicated. Of the values that were above the phototherapy treatment threshold, gas machine results were matched by laboratory values above the threshold (True Positive) and 31% were not matched by the lab (False Positive), and 0% were (False negative).

Conclusion: The study shows that the gas machine analyser is a reliable method for accurately measuring bilirubin values, it provides valid and precise bilirubin measurements and can guide timely clinical decision and intervention for hyperbilirubinemia. This simple cost-effective method can significantly reduce the waiting time to make critical clinical decisions, improve clinical outcomes and enhance patients' satisfaction. The decisions for exchange transfusions may still be required to be

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confirmed by using laboratory analysis.

Keywords: Neonates, Hyperbilirubinemia, Capillary Sampling, Venous Sample, Laboratory Testing, Blood Gas Machine Analyser.

INTRODUCTION

Hyperbilirubinemia is a common problem in the neonate and can be a life-threatening condition if not timely treated. Nearly 60% of the newborns have jaundice in early weeks of life and need testing for their bilirubin level to decide whether they would need treatment [1,2]. The measurement of serum total bilirubin is one of the most frequently performed tests in newborns. Currently, there are different methods for measuring bilirubin concentration in the neonatal units; invasive by venous sampling and noninvasive by capillary sampling and transcutaneous bilirubin-meter [3-15]. Venous sample are usually sent to the laboratory to be analysed via special chemical reactions and capillary samples usually processed in the neonatal unit using the blood gas machine analyser which is almost always present in all neonatal units close to patients. The motivation of our study was the paucity of research undertaken to evaluate whether the traditional laboratory testing is superior to the blood gas machine analyser in determining bilirubin values and clinical intervention for hyperbilirubinemia in the neonatal population. The traditional gold standard to assess bilirubin concentration in neonates is testing serum bilirubin level via laboratory analysis and is believed to be sufficiently accurate, however, it is laborious and time-consuming method, it also requires taking larger blood volume (0.5-1ml) and takes longer time to obtain the results "minimum of 1-2 hours", and sometimes longer in particularly during the busy times. However, bilirubin concentration can be accurately measured by capillary sampling using blood gas analyser, that usually requires a much smaller blood volume (around 0.1 ml), which is an important consideration in the neonatal population. Capillary sample and bilirubin measurements using the blood gas machine analyser can also be performed by trained nurses who can share the workload with doctors. It also significantly takes less time to obtain a result, "around 1-2 minutes", which is a crucial factor in making prompt clinical decision and enhance clinical outcome and parents' satisfaction. While, blood gas analyser testing has significant advantages, during phototherapy treatment period when multiple values needed per day, it is also cost-effective method.

AIM OF THE STUDY

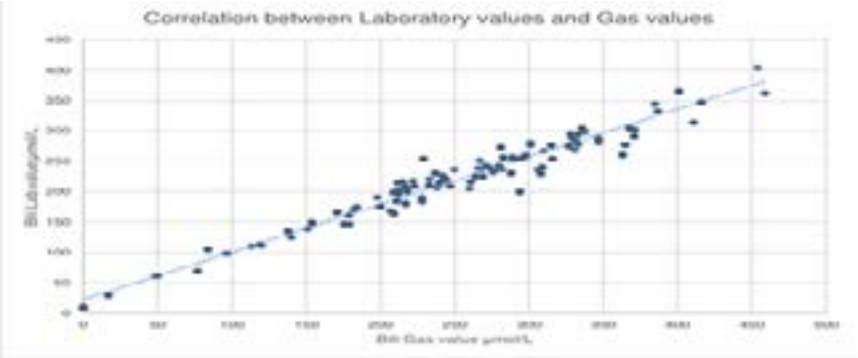
The Aim of this research project was to determine the correlation of two methods of measuring bilirubin concentration in neonates "the laboratory and blood gas analyser" in particular there is paucity of research carried out in this area. This to determine whether the current gold standard "laboratory test" for determining bilirubin values in the neonate can be replaced with a blood gas-analysis machine which is commonly placed on the neonatal intensive care unit, and to determine if the gas machine method is safe and reliable, before implementing the change away from the laboratory method for making clinical decision in jaundiced babies.

METHODS

The main aspirations that motivated this study are the several benefits in patients' care by adopting a new and safe strategy of testing bilirubin values accurately. The ultimate purpose was to determine reliability of blood gas analyser in accurately measuring blood bilirubin values and verify its measurements against the laboratory results to provide evidence before it is relied upon in clinical practice. An ethical approval has been obtained to undertake a retrospective quantitative research study, 228 paired bilirubin measurements from hospitalized neonates were available for analysis. Bilirubin measurements obtained from the laboratory and compared with the results from four gas machine analysers. We included patients tested at the same time by both laboratory and blood gas analyser. Patients tested by only either method were excluded from the study. This was to verify whether bilirubin measurement using blood gas analyser was accurate enough to determine treatment thresholds and can be relied upon for medical interventional therapy in jaundiced babies and to compare the paired samples results. This was to ensure the gas machine readings wouldn't result in a patient missing out on treatment when they need it (false negative) and wouldn't treat a patient with phototherapy that doesn't require it (false positive).

RESULTS

During the study period, 228 paired bilirubin measurements from hospitalized neonates were available for analysis. Figure (1) the correlation scatter graph clearly shows incredible matching of the two methods of bilirubin testing. The R value of 0.978 demonstrates a very high correlation value between both tests, further most of the time they agree on treatment decisions. There was little to zero correlation between the μmol/L difference between the two methods and when phototherapy treatment is indicated.



DISCUSSION

The majority of values were more positive in the gas machine method when compared to the laboratory method. The most common range of values was when the gas machine values were more positive by between +35 and +45 μmol/L, with 61% data points falling in this range. The data showed signs of a normal distribution with some troughs in the ranges between +15 and +35 μmol/L, it was reasonable to expect a normal distribution pattern to emerge with continuing data points. The correlation scatter graph clearly shows incredible matching of the two methods of bilirubin testing. The R value of 0.978 demonstrates a very high correlation value between both tests, further most of the time they agree on treatment decisions (Figure 1). There was little to zero correlation between the μmol/L difference between the two methods and when phototherapy treatment is indicated. Further, that the gas analysis found to overestimate the laboratory values above 100 μmol/L at times. Some of these values can be explained by the gas machine analysis being quicker to perform than the laboratory analysis and that the laboratory values came back many hours after the sample was taken, and in this time the sample may well have undergone a partial breakdown of the bilirubin by ambient light. This could reflect an even more accurate result obtained by gas machine analyser than the current laboratory method.

In our data sample where the difference between the methods was great enough to change the value over the patient's own treatment threshold, occurred when the laboratory value indicates the patient doesn't need phototherapy, but the gas value overestimates, and pushes the value above the treatment threshold, which we have termed as (False Positive), whereby the reverse case was termed (False Negative). The majority of the data reflected values wouldn't indicate phototherapy treatment (True Negatives). Of the values that were above the phototherapy treatment threshold, gas machine results were matched by laboratory values above the threshold (True Positive) and 31% were not matched by the laboratory (False Positive), and 0% were (False negative). Thus, there were no instances where the gas machine underestimated the laboratory values to indicate that a patient would not need phototherapy. This means that a gas machine value below the treatment threshold is very likely to be matched by a laboratory value below the phototherapy treatment threshold.

Furthermore, the laboratory test requires taking larger blood volume (0.5-1ml) and takes longer time to obtain the results "minimum of 1-2 hours", and sometimes longer in particularly during the busy times. However, the blood gas analyser, usually requires a capillary sample and much smaller blood volume around (0.1 ml), thus it would prevent the harm from unnecessarily drawing a larger blood sample and this would prevent iatrogenic anemia in vulnerable premature babies. It also takes significantly less time to obtain a result, "around 1-2 minutes", unlike laboratory test (1-2 hours), which is a crucial factor in making prompt clinical decision and enhance clinical outcome which is an important consideration in the neonatal population. Capillary sample can also be performed by trained nurses who can share the workload with doctors. Importantly, this would mean the neonate is taken off phototherapy sooner, coupled with the benefit of freeing up the bed for another patient. According to the NHS costs of running a laboratory bilirubin test is (approximately £0.80) and the cost of a 24 hour stay on neonatal intensive care unit is (around £900) and therefore from a purely fiscal perspective a faster result time may mean a faster and timely discharge and avoiding unnecessary long hospital stay thus saving the bed cost. It is a clear that there is a need to change practice by adopting new safe and reliable method to improve the quality of patients' care, as now it is proven that bilirubin measurements using gas analyser is satisfactorily accurate.

CONCLUSION

Hyperbilirubinemia is a quite common problem in the neonates, it can be a life-threatening condition. Bilirubin in high concentration is toxic to the brain and might cause irreversible neurological damage and lifelong morbidities, if not timely treated. A fast and reliable method to accurately measure bilirubin values is required to determine timely treatment and interventional therapy. This study shows that the gas machine analyzer is a reliable method to accurately determine hyperbilirubinemia, it produces valid bilirubin measurements and can effectively guide timely clinical decision and intervention in neonatal jaundice. The decisions for exchange transfusions may still be required to be confirmed by using laboratory analysis. This simple change has several advantages including significant reduction in waiting time to obtain results and to make clinical decisions. More importantly it would prevent the harm from unnecessarily drawing a larger blood sample and this would prevent iatrogenic anemia in vulnerable premature babies. This safe simple and cost-effective method would improve clinical outcomes and enhance patient satisfaction.

LIMITATION OF THE STUDY

Larger sample of patients may be required for future research.

CONFLICTS OF INTEREST AND SOURCE OF FUNDING

None has been declared.

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