

TEG 6S System in Neonates and Premature Infants: A Comprehensive Literature Review

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1 Introduction

The Thromboelastograph (TEG) 6S system, developed by Haemonetics, is a point-of-care device designed to assess blood coagulation by measuring the viscoelastic properties of whole blood. It is widely utilized in critical care settings, such as pediatric cardiac surgery and extracorporeal life support (ECLS), to guide transfusion and anticoagulation therapies. The system employs citrated blood samples, where citric acid prevents clotting, and clotting factors are reactivated for analysis. This report addresses the use of TEG 6S in neonates (infants less than 1 month old) and premature infants (born before 37 weeks gestation), focusing on blood draw methodologies, citric acid use, and clinical applications.

2 Objective

To provide a detailed review of published literature on the TEG 6S system in neonates and premature infants, emphasizing blood collection, citric acid use, and coagulation monitoring efficacy, based on five provided studies and additional relevant literature.

3 Methodology

Five PubMed articles were analyzed in depth, covering TEG 6S applications in pediatric populations, including neonates. Additional literature searches were conducted using PubMed and web searches with queries such as “TEG 6S premature infants” and “thromboelastography premature neonates” to identify studies specific to premature infants. Studies were evaluated for relevance to neonates, premature infants, TEG 6S use, blood draw methods, and citric acid application.

4 Detailed Analysis of Provided Studies

4.1 Pediatric Thromboelastograph 6s and Laboratory Coagulation Reference Values

- Citation: Moynihan K, et al. *Arch Pathol Lab Med.* 2021;145(11):1413-1423 ([PubMed](#)).
- Design: Prospective, observational, single-center study.
- Population: 254 healthy children, including neonates (<1 month), infants (1 month–1 year), and older age groups, undergoing general anesthesia from January 2017 to January 2019.
- Objective: To generate reagent-analyzer-specific pediatric reference intervals (RIs) for TEG 6S and coagulation parameters.
- Methods: Venous blood samples were collected in citrated tubes for TEG 6S (Kaolin, Kaolin-Heparinase, Rapid, Functional Fibrinogen assays) and coagulation parameters (activated partial thromboplastin time, prothrombin time, thrombin clotting time, EchiS time, antithrombin activity, fibrinogen concentration) using Instrumentation Laboratory ACL-TOP analyzers. Statistical analyses included quantile regression to establish RIs.
- Findings:
 - Generated age-specific RIs for TEG 6S parameters, with neonates showing distinct coagulation profiles compared to older children.
 - All TEG 6S variables (e.g., reaction time, maximum amplitude) varied with age, reflecting developmental hemostasis.
 - Citrated blood samples were used without reported issues, indicating reliable blood collection and clotting factor reactivation.
 - Observed variations reinforced the need for laboratory-specific RIs to improve clinical result interpretation.
- Relevance: Directly addresses TEG 6S in neonates, providing foundational reference values essential for clinical use. Premature infants were not explicitly mentioned, but the neonatal group may include some preterm infants.
- Blood Draws and Citric Acid: Citrated blood samples were standard, with no reported complications related to citric acid or clotting factor reactivation, confirming the method’s reliability in neonates.

4.2 Evaluation of Thromboelastography 6s in Pediatric Cardiac Surgery

- Citation: Lindhardt R, et al. *Acta Anaesthesiol Scand.* 2022;66(10):1234-1242 ([PubMed](#)).
- Design: Retrospective study.

- Population: 279 infants undergoing congenital cardiac surgery with cardiopulmonary bypass (CPB), with a median age of 66 days (IQR: 10–132 days) for those receiving cryoprecipitate.
- Objective: To evaluate the prognostic value of TEG 6S Functional Fibrinogen-Maximum Amplitude (TEG-FF-MA) for predicting intraoperative bleeding and cryoprecipitate transfusion needs.
- Methods: TEG-FF-MA was measured at multiple intraoperative time points using citrated blood samples. Bleeding (>10 ml/kg) and cryoprecipitate use were recorded. Sensitivity, specificity, and predictive values were calculated for a TEG-FF-MA threshold of 10.0 mm.
- Findings:
 - TEG-FF-MA at 10.0 mm predicted bleeding with 74% sensitivity, 56% specificity, 80% positive predictive value, and 47% negative predictive value.
 - Cryoprecipitate use was associated with younger age and higher surgical complexity, suggesting a higher bleeding risk in neonates.
 - Challenges were noted in establishing a clear TEG-FF-MA threshold due to variability in infant coagulation profiles.
- Relevance: Includes neonates (as young as 10 days), relevant to cardiac surgery settings. Premature infants may be included but are not explicitly identified, limiting specific conclusions for this subgroup.
- Blood Draws and Citric Acid: Citrated blood samples were used for TEG 6S analysis, with no reported issues, indicating the method’s suitability for young infants.

4.3 Detection of Early Incomplete Heparin Reversal in Congenital Cardiac Surgery

- Citation: Magunia H, et al. *Thromb Res.* 2019;182:33-38 ([PubMed](#)).
- Design: Retrospective, observational study.
- Population: 40 children with a median age of 130 days (IQR: 13–310 days) undergoing congenital cardiac surgery.
- Objective: To compare TEG 6S parameters with conventional coagulation tests (e.g., activated clotting time, anti-Xa) for monitoring heparin reversal post-CPB.
- Methods: Blood samples were collected before and after CPB, and after protamine administration, using citrated tubes for TEG 6S and conventional tests. Correlations between TEG parameters and conventional tests were analyzed.
- Findings:
 - No clinically relevant correlation was found between TEG 6S parameters and conventional coagulation tests for heparin reversal monitoring.
 - The study highlighted the rapid result delivery of TEG 6S but recommended further research to evaluate its efficacy in reducing blood loss.

- Relevance: Includes neonates (as young as 13 days), but premature infants are not specifically addressed. The lack of correlation with conventional tests suggests limitations in TEG 6S for heparin monitoring in this context.
- Blood Draws and Citric Acid: Citrated blood samples were used without reported issues, confirming the reliability of this method in young children.

4.4 Coagulation Monitoring in Pediatric Extracorporeal Life Support

- Citation: Moynihan K, et al. *Perfusion*. 2017;32(8):675-685 ([PubMed](#)).
- Design: Prospective and retrospective study.
- Population: Children (<18 years) on extracorporeal life support (ECLS), likely including neonates due to common indications (e.g., meconium aspiration).
- Objective: To compare coagulation tests (activated clotting time, activated partial thromboplastin time, anti-Xa, thrombin time, TEG 6S) for evaluating heparin effects in pediatric ECLS.
- Methods: Blood samples were collected in citrated tubes for TEG 6S and other coagulation tests. TEG 6S parameters (ratio and delta reaction times) were correlated with heparin dose.
- Findings:
 - TEG 6S parameters showed the best correlation with heparin dose (11.9% and 9.9% variation explained), though much variation remained unexplained.
 - Lower anti-Xa levels were associated with mortality and thrombotic complications, highlighting the importance of effective anticoagulation monitoring.
- Relevance: Likely includes neonates, as ECLS is common in this group, but premature infants are not explicitly mentioned. TEG 6S appears useful for heparin monitoring in ECLS.
- Blood Draws and Citric Acid: Citrated blood samples were used without reported issues, indicating the method's effectiveness in this population.

4.5 Diagnostic Agreement Between TEG5000 and TEG6S in Pediatric Cardiac Surgery

- Citation: Benegni S, et al. *Pediatr Cardiol*. 2025;46(1):123-130 ([PubMed](#)).
- Design: Prospective, non-inferiority cohort study.
- Population: 30 pediatric patients undergoing cardiac surgery, with a median age of 206 days (IQR: 20–597 days).
- Objective: To evaluate agreement between TEG5000 and TEG6S for hemostasis assessment.
- Methods: Paired citrated blood samples were analyzed using TEG5000 and TEG6S at one hour and 24 hours postoperatively. Six TEG parameters (R kaolin time,

R kaolin heparinase time, K kaolin time, K kaolin heparinase time, maximum amplitude kaolin, maximum amplitude kaolin heparinase) were compared.

- Findings:
 - Substantial agreement was observed in maximum amplitude and K time parameters, suggesting TEG6S and TEG5000 are interchangeable.
 - No issues were reported with citrated blood samples, confirming the reliability of the blood collection method.
- Relevance: Includes neonates (as young as 20 days), validating TEG 6S reliability in cardiac surgery. Premature infants are not specifically identified.
- Blood Draws and Citric Acid: Citrated blood samples were used without reported issues, reinforcing the method's suitability for young infants.

5 Additional Literature on Thromboelastography in Premature Infants

To address the interest in premature infants, additional studies on thromboelastography (not necessarily TEG 6S) were reviewed:

5.1 Thromboelastographic Profiles of Premature Infants

- Citation: Sokou R, et al. *J Matern Fetal Neonatal Med.* 2015;28(15):1777-1781 ([PubMed](#)).
- Population: 49 premature infants, 16 with intracranial hemorrhage.
- Findings: Premature infants showed effective hemostatic function in the first 21 days, with those having intracranial hemorrhage exhibiting a hypercoagulable state (shorter reaction and maximum amplitude times). Clot lysis time correlated with gestational age.
- Relevance: Directly addresses premature infants, suggesting thromboelastography's utility, though the specific TEG device is not specified.
- Blood Draws and Citric Acid: Citrated blood samples were likely used (standard for thromboelastography), with no reported issues.

5.2 Reference Intervals for Thromboelastography in Premature Neonates

- Citation: Motta M, et al. *Early Hum Dev.* 2017;115:60-63 ([PubMed](#)).
- Population: 118 preterm neonates.
- Findings: TEG parameters showed no significant differences between early-preterm and moderate-/late-preterm neonates, except for higher fibrinolysis in early preterm. Hemostasis was balanced despite lower pro- and anti-coagulant protein levels.
- Relevance: Provides reference intervals for premature infants, supporting thromboelastography's applicability, but does not specify TEG 6S.

- Blood Draws and Citric Acid: Citrated blood samples were used, with no reported issues.

5.3 Comparison of TEG 6S vs. TEG 5000 in Pediatric Cardiac Surgery

- Citation: Baryshnikova E, et al. *Front Pediatr.* 2022;10:1000530 ([PMC](#)).
- Population: 100 pediatric patients (< 18 years), with 27% neonates (< 30 days).
- Findings: TEG 6S correlated well with TEG 5000, with rewarming maximum amplitude associated with perioperative bleeding endpoints. Citrated whole-blood samples were used.
- Relevance: Includes neonates, confirming TEG 6S reliability in cardiac surgery, but does not specify premature infants.
- Blood Draws and Citric Acid: Citrated blood samples were used without issues.

6 Analysis of TEG 6S in Neonates and Premature Infants

6.1 Neonates

The provided studies and additional literature confirm that TEG 6S is effectively used in neonates, particularly in high-risk settings like cardiac surgery and ECLS. Key findings include:

- Reference Intervals: Age-specific RIs for neonates enhance the accuracy of TEG 6S result interpretation ([Moynihan 2021](#)).
- Prognostic Value: TEG 6S predicts bleeding and guides fibrinogen supplementation in neonatal cardiac surgery ([Lindhardt 2022](#)).
- Reliability: TEG 6S is interchangeable with TEG 5000, supporting its use in neonates ([Benegni 2025](#); [Baryshnikova 2022](#)).
- Heparin Monitoring: TEG 6S correlates with heparin dose in ECLS, though variability remains ([Moynihan 2017](#)).

The use of citrated blood samples is standard, with no reported issues related to citric acid or clotting factor reactivation in neonates.

6.2 Premature Infants

Evidence specific to TEG 6S in premature infants is limited. However:

- General thromboelastography studies ([Sokou 2015](#); [Motta 2017](#)) suggest that premature infants have balanced hemostasis, implying TEG 6S could be applicable.
- Studies including neonates (e.g., [Lindhardt 2022](#)) may encompass premature infants, especially in cardiac surgery contexts, but lack explicit focus on prematurity.
- Reference intervals for thromboelastography in premature neonates ([Motta 2017](#)) provide a foundation for interpreting TEG 6S results.

No studies reported issues with citric acid use or clotting factor reactivation in premature infants, aligning with standard TEG 6S protocols.

7 Discussion

The TEG 6S system is well-documented in neonates, providing critical coagulation data in complex clinical scenarios. Its cartridge-based, automated design enhances ease of use in neonatal intensive care units (NICUs). For premature infants, while direct TEG 6S studies are scarce, the balanced hemostasis observed in general thromboelastography studies supports its potential utility. The lack of specific reference intervals for premature infants highlights a research gap. The citration process appears reliable across populations, with no adverse effects noted.

8 Conclusion

Research supports the use of TEG 6S in neonates for coagulation monitoring, particularly in cardiac surgery and ECLS, with established reference intervals and prognostic capabilities. For premature infants, general thromboelastography studies suggest applicability, but specific TEG 6S data are limited. The citric acid-based blood draw process is standard and effective. Further studies are needed to develop premature-specific reference ranges and validate TEG 6S in this population.

9 Recommendations

- Conduct prospective studies focusing on TEG 6S in premature infants to establish reference intervals and clinical efficacy.
- Include gestational age data in future TEG 6S studies to differentiate premature from term neonates.
- Explore TEG 6S applications in NICU settings for premature infants with bleeding or thrombotic risks.

References

- [1] Moynihan K, et al. Pediatric Thromboelastograph 6s and Laboratory Coagulation Reference Values. *Arch Pathol Lab Med.* 2021;145(11):1413-1423. [PubMed](#).
- [2] Lindhardt R, et al. Evaluation of Thromboelastography 6s prognostication of fibrinogen supplementation in pediatric cardiac surgery. *Acta Anaesthesiol Scand.* 2022;66(10):1234-1242. [PubMed](#).
- [3] Magunia H, et al. Detection of early incomplete heparin reversal following congenital cardiac surgery. *Thromb Res.* 2019;182:33-38. [PubMed](#).
- [4] Moynihan K, et al. Coagulation monitoring correlation with heparin dose in pediatric extracorporeal life support. *Perfusion.* 2017;32(8):675-685. [PubMed](#).

Table 1: Summary of Key Studies on TEG 6S and Thromboelastography in Neonates and Premature Infants

Study	Population	TEG Device	Key Findings	Relevance
Moynihan 2021	Neonates (<1 month)	TEG 6S	Age-specific RIs for TEG 6S	Neonatal reference values
Lindhardt 2022	Infants (median 66 days)	TEG 6S	Predicts bleeding in cardiac surgery	Includes neonates
Magunia 2019	Children (median 130 days)	TEG 6S	Limited correlation with conventional tests	Includes neonates
Moynihan 2017	Children (<18 years)	TEG 6S	Correlates with heparin dose in ECLS	Likely includes neonates
Benegni 2025	Children (median 206 days)	TEG 6S	Interchangeable with TEG 5000	Includes neonates
Sokou 2015	Premature infants	Unspecified TEG	Effective hemostasis	Premature infant data
Motta 2017	Premature neonates	Unspecified TEG	Balanced hemostasis	Premature reference intervals
Baryshnikova 2022	Pediatric neonates (27%)	TEG 6S	Reliable in cardiac surgery	Includes neonates

- [5] Benegni S, et al. Diagnostic Agreement Between TEG5000 and TEG6S in Pediatric Cardiac Surgery. *Pediatr Cardiol.* 2025;46(1):123-130. [PubMed](#).
- [6] Sokou R, et al. Thromboelastographic profiles of premature infants with and without intracranial hemorrhage. *J Matern Fetal Neonatal Med.* 2015;28(15):1777-1781. [PubMed](#).
- [7] Motta M, et al. Reference intervals of citrated-native whole blood thromboelastography in premature neonates. *Early Hum Dev.* 2017;115:60-63. [PubMed](#).
- [8] Baryshnikova E, et al. Comparison of Thromboelastography Devices TEG®6S vs. TEG®5000 in Pediatric Patients Undergoing Cardiac Surgery. *Front Pediatr.* 2022;10:1000530. [PMC](#).