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Rat Tail Bleeding Models: A Comprehensive Review

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ABSTRACT

Rat tail bleeding models are commonly preferred by researchers for evaluating efficacy of potential hemostatic and anticoagulant agents. Although they are used frequently, there are inconsistencies in terms of methodology and terminology among different studies. As hemostatic and anticoagulant agents are useful to decrease deaths from bleeding, standardization of rat tail bleeding models is crucial for reliability of research. In 2025, a targeted research was performed in the PUBMED database using the query "rat tail bleeding". The abstracts and methods of 172 articles were examined to identify studies specifically using rat tail bleeding models and 70 relevant articles were selected. Literature review revealed significant variations between studies using the same method including other studies implementing the same model and naming it differently. Additionally, differences in tools used, incision depths, and bleeding assessment techniques contribute to inconsistencies affecting reliability of these models. The literature on rat tail bleeding models lacks consistency and standardization, which affects the reliability and reproducibility of research. Many studies use different names for the same model, which can confuse some researchers. Furthermore, there are variations in methodology even among studies using the same model. To address these issues, standardization of rat tail bleeding models is necessary as they are essential for evaluating hemostatic and anticoagulant agents.

Keywords: Bleeding, Hemostasis, Hemostatic agents, Rat tail bleeding models, Standardization.

Introduction

There are various types of bleeding models in order to assess efficacy of hemostatic and anticoagulant agents such as saphenous vein bleeding model (Buyue et al., 2008), liver laceration bleeding model (Sener et al., 2022), femoral artery bleeding model (Binnetoglu et al., 2021), renal vein bleeding model (Sener et al., 2023). Even though there are lots of different bleeding models, tail bleeding models are one of the most commonly used ones because of simplicity of implementation, widespread usage in literature (Mohammed et al., 2020). Additionally, bleeding models can be implemented in different animals like swine (Naar et al., 2022), rabbit (Nogawa et al., 2022), mouse (Mashausi et al., 2022) or rat (Gedar Totuk et al., 2020). In this article, we focused on rat tail bleeding models.

Rat tail bleeding models are commonly used in research to measure bleeding time and bleeding volume (Stagaard et al., 2023; Tiryaki et al., 2025). These models involve inducing uncontrolled bleeding from the tail of a laboratory rat. There are several types of rat tail bleeding models, each serving a specific research purpose (Stagaard et al., 2023). The main purpose of using these models is measuring efficacy of potential hemostatic and anticoagulant agents. Additionally, the number of review articles and studies for standardization of rat tail bleeding models are not sufficient in the literature in contrast to

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tail bleeding models in mice (Stagaard et al., 2023). Because of these reasons, in this article, we focused on rat tail bleeding models used in literature and listed them in following paragraphs.

Rat Tail Transection Model

The rat tail transection model provides a controlled environment for evaluating the effectiveness of various hemostatic agents in stopping bleeding (Stagaard et al., 2023). In this method, experimenters completely cut a portion of the rat tail and the blood coming from the rat tail is obtained into a piece of cotton/filter paper to record bleeding time or the rat tail may be put directly into an isotonic solution called “immersion technique” (Garcia et al., 2019; Greene et al., 2010; Wu et al., 2022).

Rat Tail Vein Bleeding Model

Rat tail vein bleeding model involves making a partial cut targeting tail veins with/without a template device in order to start bleeding (Johansen et al., 2016). This allows researchers to study venous bleeding and assess the effects of various treatments or interventions on venous hemostasis. It is used to study various aspects of coagulation, thrombosis, and the effects of anticoagulant drugs. The rat tail vein bleeding model is also called the “tail vein transection (TVT) model” according to literature (Zintner et al., 2019).

Rat Tail Artery Bleeding Model (Arterial Tail Bleeding Model)

In this model, a tail artery, which carries oxygenated blood, is specifically targeted and transected to induce arterial bleeding (Ito et al., 2018). In this model, the tail artery is specifically targeted. This allows researchers to study arterial bleeding and assess the effects of various treatments or interventions on arterial hemostasis.

Rat Tail Incision Bleeding Model

Rat tail incision bleeding model is another model which is used frequently in experiments to evaluate bleeding time after applying various hemostatic agents. In this model, a small incision is made on the tail of a rat, and the time it takes for the incision to stop bleeding is measured (Bubueanu et al., 2019; Chng et al., 2022; Meijers et al., 2023). The bleeding time can be measured by both using filter paper and immersion technique (Bubueanu et al., 2019; Chng et al., 2022; Meijers et al., 2023).

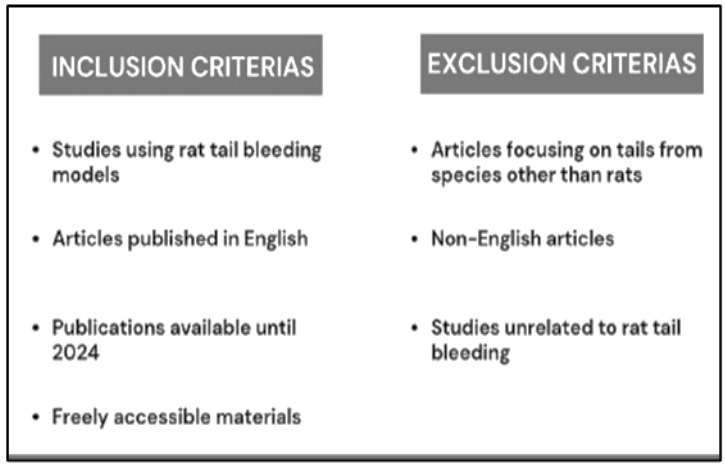
According to our examination on the PubMed database, there is not a standardization in rat tail bleeding models while even the same models are named differently by authors (Bian et al., 2022; Kuziej et al., 2010; Morgan et al., 2015). Because the number of deaths caused by post-traumatic bleeding is significant (Moore et al., 2021), useful hemostatic agents are a necessity and standardization of rat tail bleeding models are crucial as these models are frequently used in the literature. With this review, we aimed to list every single rat tail bleeding model to try to solve confusion which is found in literature by discussing them in detail and creating an important guideline for further studies aiming to show efficacy of hemostatic/anticoagulant agents or to standardize different rat tail bleeding models.

Methods

In November 2025, a focused search was conducted in the PUBMED database using the query "rat tail bleeding," with the “free full text” filter applied to ensure accessibility. This initial search yielded 172 articles in English. Abstracts and material methods of these articles were reviewed to identify studies explicitly using rat tail bleeding models. Based on this review, 70 articles relevant to the topic were selected, while studies unrelated to rat tails or those focusing on mouse tails were excluded (Figure 1).

Figure 1.

Inclusion and exclusion criteria.



During this analysis, it was noted that many studies used identical or highly similar methods despite being described

under different names. These overlapping methodologies were grouped under common categories, enabling a streamlined classification. This classification framework highlights both standard and unique methods found in the literature, providing a comprehensive guide for researchers.

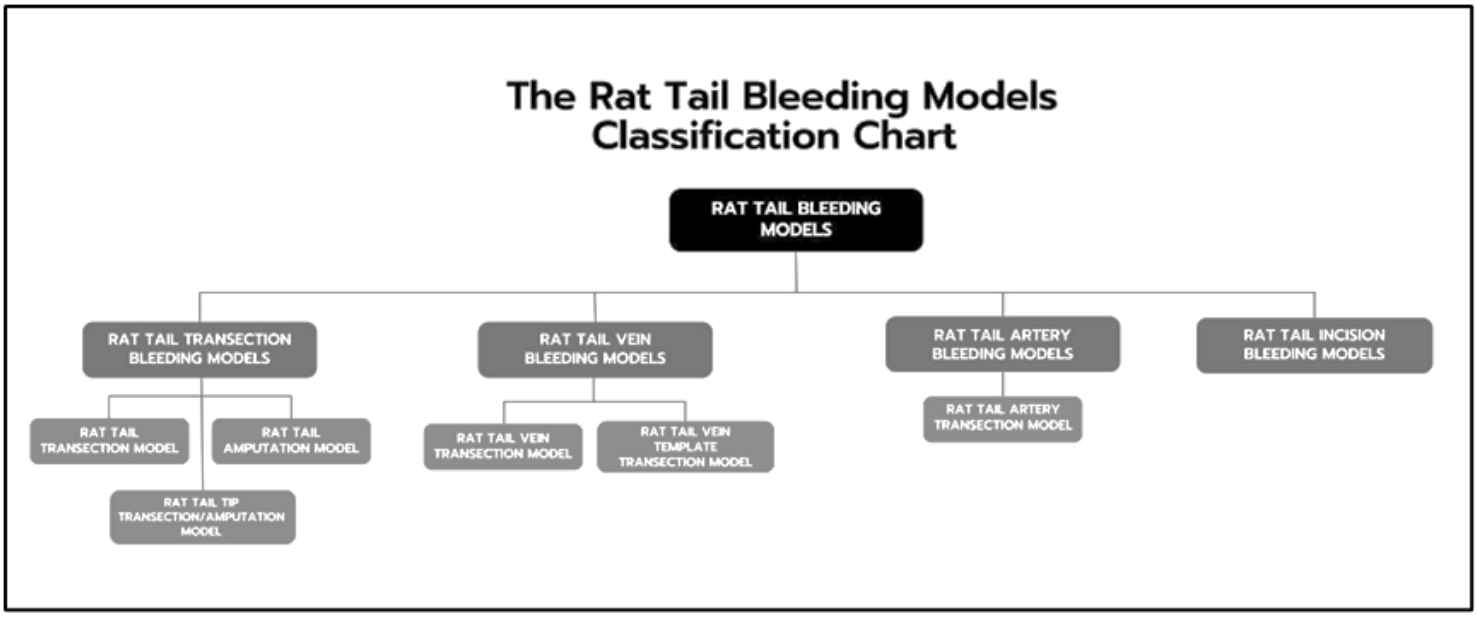
Results

Following the screening process, a total of 70 articles specifically related to rat tail bleeding models were identified. These articles encompassed a range of bleeding methods employed in studies, allowing for a detailed analysis of the various experimental techniques used. In reviewing the methodologies, it became evident that while many studies employed distinct names for their bleeding models, numerous methods were fundamentally identical in execution. These models were consolidated under unified categories to streamline the classification and reduce redundancy.

This classification resulted in a clearer organization of rat tail bleeding models, capturing both widely recognized and unique approaches used in the field (Figure 2). By consolidating identical methods and categorizing distinct techniques, the review establishes a comprehensive reference framework. This framework not only aids in distinguishing between different methodologies but also offers researchers a structured guide to select the most suitable model for their own experiments involving rat tail bleeding.

Figure 2.

Different types of rat tail bleeding models found in the literature.



Discussion

Rat tail bleeding models provide valuable insights into the complex processes of hemostasis and coagulation and are essential for 1) evaluating the effectiveness of hemostatic agents, 2) conducting bleeding time experiments and assessing drug efficacy, and 3) studying bleeding disorders and conditions associated with abnormal clotting (Morgan et al., 2015). Researchers select the appropriate model based on the specific research questions they aim to address, as well as the level of control and bleeding severity required for their study.

According to the literature, various tail bleeding models have been described by different researchers (Mohammed et al., 2020). Interestingly, some of these models are referred to by different names despite employing identical methodologies (Bian et al., 2022; Kuziej et al., 2010; Morgan et al., 2015). Moreover, certain methods of tail bleeding models have been utilized by only a limited number of researchers (Lauritzen et al., 2009). This lack of consistency highlights that rat tail bleeding models are not sufficiently standardized, and a clear, unified terminology is yet to be established. In the following paragraphs, different tail bleeding models in rats and variations of them

were explained in detail along with examples found in the literature.

Rat Tail Transection Model

Rat tail transection model is the most frequently used rat tail bleeding model for assessing new therapeutic interventions for bleeding disorders (Lauritzen et al., 2009). This model helps evaluate the efficacy of hemostatic agents, bleeding times, and blood loss after tail transection (Mohammed et al., 2020; Toomey et al., 2006). Transection tends to yield longer bleeding times and higher amounts of bleeding than small incisions, which can be advantageous for testing efficacy of potential hemostatic and anticoagulant agents (Zintner et al., 2019).

Practical considerations include the method of tail transection, as using guillotines may crush tissue and introduce variability in bleeding time (Gedar Totuk et al., 2020). Additionally, variations in transection distance, as more proximal cuts lead to longer bleeding times, underscore the need for consistency to avoid confounding factors like the rat's weight (Greene et al., 2010). Standardized transection force across animals is also critical to prevent skewed results (Greene et al., 2010).

A Model Variations

In the literature, "rat tail transection model" may be termed as "rat tail amputation model" or "rat tail tip amputation model" in terms of complete transection (Bian et al., 2022). "Rat tail amputation model" frequently refers to a complete transection of the tail usually from more proximal parts (Du et al., 2014) even though there are some exceptions (Jimenez-Martin et al., 2022). In contrast, "rat tail tip-amputation" (Sogut et al., 2015), "rat tail-tip transection" (Coleman et al., 2020) or "rat tail-tip bleeding" (Rossato et al., 2022) models can be implemented by creating a complete transection from tail tip (distal parts of the rat tail). Additionally, transections made from any location of the tail can be called the "rat tail transection model" without looking for another criteria (Ma et al., 2021).

Additionally, there is a study that uses a model implementing the identical methodologies of rat tail transection model along with calling their model as "tail-cut rat model of bleeding". This naming is actually different from other studies of rat tail bleeding models and calling this "rat tail transection model" can be more accurate according to literature (Reck et al., 2014).

Another variation found in literature is the type of transection. There are mainly two types of transection as complete (Lin et al., 2019) and partial transection (Oliveira et al., 2021). Actually, "rat tail transection" primarily refers to complete transection but some articles identify partial transection, too (Oliveira et al., 2021). Even though it is not directly called "partial transection" by researchers, an article (Oliveira et al., 2021) indicates "a partial 4 mm transverse incision" which can be categorized as partial transection as the word "incision" is usually implemented longitudinally in the literature (Chng et al., 2022).

Complete Transection: This method involves a complete cut from any distance of the tail, causing immediate, uncontrolled bleeding (Saito et al., 2016). Often performed with a sterile lancet (Hoppensteadt et al., 2014) even though guillotine (Gedar Totuk et al., 2020), nail scissors (Lauritzen et al., 2009) and other types of scissors (Jeon et al., 2021) are used by different researchers.

Complete transection of the rat tail induces substantial bleeding, enabling evaluation of candidate hemostatic and anticoagulant agents (Holly et al., 2019). In the experimental literature, 'tail transection' commonly refers to a tail-cut procedure performed at a defined distance from the tip, and is considered a more severe injury than incision-based approaches (Mohammed et al., 2020).

Partial Transection: In literature, "partial transection" is mainly used to indicate a small transverse incision which is made to rat tail creating an immediate, uncontrolled bleeding (Oliveira et al., 2021). The bleeding time is not significant in partial transection as much as complete transection between tail cuts at the same level (Oliveira et al., 2021). Because of that, complete transection is more frequently used in literature as it causes a significant amount of bleeding which is better for evaluation of potential pharmacological agents (Chen et al., 2020; Oliveira et al., 2021).

Additionally, there is another model called "rat tail vein transection (TVT) injury model" which combines two

existing tail bleeding models: “rat tail transection model” and “rat tail vein bleeding model”. In literature, TVT injury model is not common but it is implemented in several researches (Garcia et al., 2019; Zintner et al., 2019).

Rat Tail Vein Bleeding Model

In rat tail vein bleeding model, researchers create an injury specifically at the rat tail vein and then bleeding parameters can be measured as it’s explained previously (Garcia et al., 2019).Even though it is not frequently used, there are several researchers which choose rat tail vein bleeding model in their experiments (Chng et al., 2022; Garcia et al., 2019; Zintner et al., 2019). Additionally, there are some variations in this model in terms of application like the rat tail transection model.

A Model Variations

In the literature, rat tail vein bleeding models are commonly made by template transection of tail veins such as “tail vein transection (TVT) bleeding model” (Zintner et al., 2019) and “lateral tail vein template transection model” (Garcia et al., 2019). As tail veins are specifically targeted, categorizing these models under “rat tail vein bleeding models” is more accurate even though they are combinations of “rat tail vein bleeding model” and “rat tail transection model”.

According to current research, tail vein bleeding models can be easily implemented by using a template device and calling the method as “rat tail vein template transection” (Garcia et al., 2019) even though there are some studies that do not explain the status of using a template device (Zintner et al., 2019). Additionally, lateral tail veins can be specifically targeted by researchers (Garcia et al., 2019). In this case, the tail bleeding model is called “lateral tail vein template transection model” (Garcia et al., 2019). Also, a study held by Wei Seng Chng. et al. indicates that they made a longitudinal incision on tail vein without naming their method as “rat tail vein bleeding model” (Chng et al., 2022). Lastly, there are some articles which say that they measured “rat tail vein bleeding time” without explaining their methods in detail (Li et al., 2017).

Rat Tail Artery Bleeding Model

In this model, the tail artery of the rat is specifically targeted like the rat tail vein bleeding model. An incision or puncture can be made to form an injury at the tail artery and then bleeding parameters can be evaluated. This model is uncommon, unlike other arterial bleeding models such as femoral (Abacıoğlu et al., 2016) arteries, in the literature even though an example is present (Ito et al., 2018).

A Model Variations

A research was held by Ito et al. implementing the “rat tail artery bleeding model”. In this experiment, researchers created a 1 mm incision on the artery of the ventral part of the tail at 4 cm from the tip and they named the bleeding model as “rat tail injury bleeding model” (Ito et al., 2018). Technically, an injury was created on rat tail but naming this model as “rat tail artery bleeding model” can be more accurate as tail artery was specifically targeted.

Rat Tail Incision Bleeding Model

The rat tail incision model refers to creation of a bleeding by making an incision on rat tail (Furugohri et al., 2008). After bleeding starts, bleeding parameters should be evaluated as present in all tail bleeding models (Peters et al., 2004). In contrast to rat tail artery and rat tail vein bleeding models, “rat tail incision” model is the second most common tail bleeding model in rats after “rat tail transection model” (Lee et al., 2002).

A Model Variations

In this model, length and depth of incision can vary between studies even though there are more frequently used ones (Greene et al., 2010). More commonly preferred lengths of incisions are mostly between 1-10 mm and depth of incisions are mostly between 1-2 mm according to literature (Wu et al., 2022). Another feature of the incision is the distance from the tail tip or root (Greene et al., 2010). Location of the incision is very important as it can affect the amount of bleeding (Greene et al., 2010). Despite these differences, some studies even did not specify features of the incision, adding complexity to cross-study comparisons. In order to standardize the incision, a template can be used while creating the incision.

A study was held by Meijers et al., they indicated that “a

small incision is made" without explaining other features of the incision like length and depth (Meijers et al., 2023). In addition to it, the model was named as both "rat tail injury bleeding model" and "rat tail cut bleeding model". As it is understandable, neither "tail cut" nor "tail injury" explain the methods of the bleeding experiment and complicate the comparison between different studies (Meijers et al., 2023).

Another variation found in literature is the direction of incision. In a study which is held in 2022, researchers indicated that they made a "longitudinal incision" (Chng et al., 2022). Actually, "incision" identifies specifically "longitudinal" incision rather than a "transverse" one in terms of tail bleeding models. A transverse incision made on the rat tail can be categorized as "rat tail transection model - partial transection".

Standardization Methods in Rat Tail Bleeding Models

The integration of these references in the discussion emphasizes that there is a lack of standardization in terms of rat tail bleeding models. This lack of standardization can affect results of the tail bleeding parameters and can cause false results which is very important during preclinical trials of hemostatic and anticoagulant agents (Greene et al., 2010).

First of all, in the rat tail bleeding models bleeding time and the amount of bleeding may be affected by various factors like room temperature (Frattani et al., 2013), distance of tail transection (Ghrib et al., 2001), instrument used (razor blade, scalpel, surgical knife, guillotine) (Greene et al., 2010), sharpness of the instrument used (Greene et al., 2010).

The second thing which can be done for standardization is the use of a template in "rat tail incision bleeding model" and "rat tail transection bleeding models" making a partial transection (Rodrigues et al., 2023). Using a template can standardize depth and length of the incision and help to have better experiment results (Garcia et al., 2019; Greene et al., 2010). Additionally, template use can be helpful in tail bleeding models which target specific blood vessels such as lateral tail veins (Garcia et al., 2019).

Another thing that should be taken under consideration is the tool used in the rat tail transection bleeding models. According to literature, amputation made by guillotine can overcome the dull-blade effect and help to have more standard experiment results (Greene et al., 2010). Another thing which should be taken under consideration is that guillotine can crush the tail tissue resulting impaired bleeding time even though there is not enough evidence about this claim in the literature.

Additionally, the method which is used to measure bleeding parameters is important as it can affect experiment results such as bleeding time (Greene et al., 2010). In the literature, there are several ways to measure bleeding parameters even though some of them have several advantages (Rodrigues et al., 2023). According to Greene et al., putting rat tail into an isotonic solution after creating tail injury called "immersion technique" is accepted as a better technique than using a filter paper/cotton because it doesn't traumatize the tail and has minimal risk to affect bleeding time (Greene et al., 2010).

Based on published evidence in rat tail bleeding experiments, there can be blood loss between the tail cut and measurement of bleeding parameters. This blood loss can be huge especially in tail amputations which cause more severe and rapid bleeding. In order to prevent this blood loss and standardize the experiment, the rat tail can be compressed by using a tourniquet before creation of the tail injury. After tail injury, the tourniquet can be removed and let the bleeding start. Then, the bleeding parameters can be measured. Using a tourniquet before beginning of the bleeding can obstruct the blood flow in the tail and prevent obtaining false results even though it is used more commonly to create a vessel ligation before getting a blood specimen.

Limitations of the Study

In this article, we focused on only rat tail bleeding models and tail bleeding models used in other animals, such as mice, weren't included in this study. The reason why rat tail bleeding models were included is that there are not any satisfactory review articles about tail bleeding models in rats. Because of that, the comparison between rat and mice tail bleeding models is not present in this study.

Another limitation of this study is that the PubMed

database is the only source for literature review which was done for the article. As a consequence, animal experiments which were made and published at another website rather than PubMed, were not included in this study.

One of the most important things limiting our study is that there is a confusion and lack of union in terms of terminology. Some articles apply the same tail bleeding method along with naming it different from each other (Ma et al., 2021). Additionally, in some articles, the tail bleeding model implemented in the experiment is not explained in detail, which can complicate the understanding method of the study (Saito et al., 2016; Zhang et al., 2022).

Conclusion and Recommendations

This review demonstrates that rodent tail bleeding models remain widely used for the evaluation of hemostatic and anticoagulant agents; however, substantial methodological heterogeneity exists across studies. Differences in incision site, length and depth, bleeding duration, anticoagulant regimens, and blood loss assessment techniques complicate direct comparisons and limit reproducibility. Despite these limitations, tail bleeding models continue to provide valuable preliminary data when experimental parameters are clearly defined and consistently applied. Greater methodological standardization would enhance the reliability of results and strengthen the translational relevance of preclinical bleeding research.

- Incision length, depth, and anatomical location should be standardized and explicitly reported to improve inter-study comparability.
- The type, dose, route, and timing of anticoagulant administration should be clearly described in all experimental protocols.
- A consistent and well-defined method for blood loss measurement (e.g., filter paper-based or volumetric techniques) should be adopted and justified.
- Essential animal characteristics, including strain, age, sex, and relevant housing or environmental conditions, should be reported to support reproducibility and interpretation of results.

Ethics Committee Approval: This study is a review article based on previously published studies. No new animal experiments were conducted by the authors, and therefore ethical committee approval was not required.
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Peer-review: Externally peer-reviewed.
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Declaration of Interests: The authors have no conflicts of interest to declare.
Use of Artificial Intelligence: The authors declare that no artificial intelligence–based tools were used in the generation of scientific content, data analysis, or interpretation. AI tools were used solely for language editing and grammatical improvements.

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