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Air-Lock versus Z-Track Technique for Reducing Neonatal Pain Associated with Intramuscular Vitamin K Injection: A Quasi-Experimental Study

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ABSTRACT

Objective(s): the study aimed to assess the effects of using the Z-track and Air-lock techniques in intramuscular injection on pain levels among neonates.
Methods: A quasi-experimental study was performed on 120 term neonates selected using purposive sampling, and were divided into three groups (Air-lock, Z-track, and Control) who underwent vitamin K intramuscular injection. The control group received the injection using the routine standard practice in the neonatal unit. The Neonatal / Infant pain scale used to assess the results of the study. Statistical Package for social science SPSS was used for data analysis.
Results: The results showed, the mean of pain score was lower in the Z-track technique group compared to Air-lock technique and conventional groups. The statistics showed a significant difference between the pain scores at P value= 0.000.
Conclusions: The study concluded using the Z- track and Air-lock techniques are effective as non-pharmacological methods in reducing pain associated with the neonatal vitamin K injection.
Recommendations: the study recommends that nurses need to use the Z- track and the Air-lock techniques in postnatal wards, as part of the standard intramuscular injection procedures for pain reduction.

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تقنية قفل الهواء مقابل تقنية المسار Z لتقليل ألم حديثي الولادة المرتبط بالحقن العضلي لفيتامين ك: دراسة شبه تجريبية

المستخلص

الأهداف :هدفت الدراسة إلى تقييم أثر استخدام تقنيتي المسار Z و القفل الهوائي اثناء الحقن العضلي على مستويات الألم لدى حديثي الولادة.

منهجية البحث: أُجريت دراسة شبة تجريبية على ١٢٠ حديث ولادة في فترة حمل مكتملة، تم اختيارهم باستخدام اسلوب العينة المستهدفة، وقسموا إلى ثلاث مجموعات (القفل الهوائي، المسار Z ، والمجموعة الضابطة) الذين خضعوا لحقن فيتامين ك العضلي. تلقت المجموعة الضابطة الحقنة باستخدام الممارسة الروتينية المُتبعة في وحدة حديثي الولادة. تم استخدام مقياس ألم حديثي الولادة/الرضع في تقييم نتائج الدراسة. استُخدمت الحزمة الإحصائية للعلوم الاجتماعية لتحليل البيانات (SPSS).

النتائج :أظهرت النتائج أن متوسط درجة الألم كان أقل في مجموعة تقنية المسار Z مُقارنةً بتقنية القفل الهوائي والمجموعة التقليدية، أظهرت الإحصائيات فرقًا دالا معنويا بين درجة الألم عند قيمة P = 0.000.

الاستنتاجات :خلصت الدراسة إلى أن استخدام تقنيتي المسار Z و القفل الهوائي يعتبران من الأساليب غير الدوائية الفاعلة في الحد من الألم المصاحب لحقن فيتامين ك لدى حديثي الولادة.

التوصيات :توصي الدراسة الممرضون بضرورة استخدام تقنيات المسار **Z** والقفل الهوائي في ردهات ما بعد الولادة، كجزء من إجراءات الحقن العضلي المتبعة لتخفيف الألم..

الكلمات المفتاحية: تقنية المسار زي، حديثي الولادة، تقنية قفل الهواء، الحقن العضلي..

Introduction

Pain is known as the fifth vital sign, it is an unpleasant sensation and emotional response caused by real or potential tissue injury [1]. Pain is considered a significant problem for children of all ages in all health care settings. Injection procedures are one of the most painful and fear-inducing procedures for children [2]. Most newborns infants undergo painful procedures required for routine care during the first few days of their life, these include routine intramuscular administration of vitamin K to prevent hemorrhage, blood collection from the heel, artery, or vein, and intravenous or injections through the muscle [3]. Intramuscular IM injections have numerous applications and are frequently utilized, with an estimated 16 million IM injections administered globally every year. Immunization constitutes 5% of these injections, whilst 90% are utilized for therapy [4]. Intervention techniques for pain management aimed at lowering pain must be grounded in empirical research [5]. Pharmacological and non-pharmacological methods are utilized in pain management to mitigate pain [5]. Non-pharmacological technique has been favored because of their non-invasive nature, cost-effectiveness, reliability, classification as independent nursing interventions, and absence of side effects [7].

The Z-track approach is a prevalent non-pharmacological technique utilized in injections. In this technique, the skin is retracted using the non- dominant hand at the site of injection around 2.5 cm to 3.5 cm to one side, then injecting the needle at a 90-degree angle into the muscle, and the skin is promptly released once the needle is withdrawn following the drug injection [8]. Another common non-pharmacological injection technique is the airlock technique, which involves aspirating (0.1 to 0.2 ml) amount of air following the withdrawal of the medication in the appropriate dosage into the syringe that is utilized in intramuscular injections [9,10].

The nurses employ various strategies to mitigate pain associated with intramuscular immunization and injections, such as using the z-track and the airlock techniques. However, each method will differ in their effect on the pain level during intramuscular injections [11]. Moreover, multiple studies have demonstrated that the Z technique, the 0.2 mL airlock technique, and administering an injection for a minimum of 10 seconds are efficient strategies for mitigating adverse effects in intramuscular injections [8,12].

A study conducted by Najafidolatabad et al. [13] on studying the airlock and z-track techniques effect on intramuscular injection pain, drug leakage, also ecchymosis among adult female patients. Another study by Yilmaz D. et al [8] conducted to examine the impact of Z-track approach on pain and drug leak after diclofenac sodium intramuscular administration in adult patients. However, no comparative studies were found in the literature as to which one of the two techniques is more effective on pain and drug leakage among neonates undergoing their first intramuscular injection.

Hypotheses

Neonates receiving intramuscular injections by airlock and/or Z-track techniques, experience less pain than those receiving standard technique.

Methods

Study Design and Setting

A quasi-experimental design used to assess effect of Air-lock and Z – tract techniques on pain level in neonates. This design was chosen due to practical and ethical considerations, including the need to administer vitamin K on time after birth and to avoid delaying care for random assignment. The study employed in Al Muthanna governorate / AL Muthanna health directorate, at the Maternal and Children Teaching Hospital in the post-natal ward. Neonates delivered by cesarean section are transferred to the postnatal ward which is a part of the NICU for assessment and stabilization before scheduling to be returned to their mothers/ legal guardians during which the neonate receives various procedures including IM injection of vitamin K injection making it the place where neonates receive their first intramuscular injection. The study took place at the period of November 25th 2024 to March 24th 2025.

Study Sample and Sampling

The study was carried out on healthy term neonates admitted to the post- natal ward immediately after delivery by cesarean section. A non-random sample technique was utilized to select neonates to be part of the study. After the newborn babes were put in the incubator, the pediatrician examines the newborn and provide written orders for nurses regarding injecting the neonate with vitamin K supplementation intramuscularly. Those neonates were the target of this study. The sample size was determined using G power analysis (G*Power v3.1.9 software), based on a medium effect size of 0.35, a power of 0.90, and significant level of 0.05 to ensure adequate statistical power for group comparison and was (120) term neonates allocated into the study and control groups. **Figure (1)** shows the sample flowchart.

1. Inclusion Criteria:

The researchers targeted healthy neonates delivered between 37th and 42nd weeks of gestation through cesarean section, who weights between (2500 – 3500) grams and achieved an Apgar score of 8 or more. Those who did not receive any analgesics or any invasive procedures prior to IM injection of vitamin K. this was due to the possibility of interfering with pain perception in neonates and thus affecting pain measurement.

2. Exclusion Criteria:

Neonates suffering from any Congenital anomalies, having low birth weight, considered a preterm, delivered

normal vaginal delivery, and also those who received hepatitis B vaccination prior to transfer to the postnatal ward were not included in the study.

Study Instruments

The study instrument consisted of two parts, the first part was the neonate clinical data form and the second part was Neonatal/infant pain scale NIPS.

Part I: Newborn clinical data form

The form consisted of three items reported by the observer (nurse) and including the newborn's age, gestational age in week, sex, birth weight in grams.

Part II: Neonatal/infant pain scale (NIPS)

A scale developed specifically for newborn infants. The scale consists of 6 criteria (Face Expression, cry, Patterns of Breathing, leg and arm movements, Arousal status) and is recommended to use for pain assessment in children less than 1 year old.

The following explains the scoring system using this scale: the criterion (crying) has 3 scorings (0-1- 2) however, all the other criteria have 2 scorings (0-1). A score of zero represents no pain, (1-2) is considered mild pain, (3-4) is moderate pain, and (5-7) is severe pain.

Lawrence et al. (1993) developed NIPS and the validity and reliability test were conducted by Kanbur et al [15] in their Turkish study on neonates` pain. The values of Cronbach test in the original study ranged from 0.87 to 0.95, it was reported that in the Turkish study to obtain the validity and reliability for the NIPS scale resulted as ranging from 0.83 to 0.86 using the Cronbach Alpha coefficient test.

Data Collection

Before starting the study, the purpose of the study, the content of the forms, the interventions and how the data obtained in the study will be used were explained to the primary caregiver of the newborns and then their verbal and informed consent was obtained. Explaining to the primary caregiver that participation and withdrawals is their choice and without any consequences and the participation is without any sentiments or rewards. Only Neonates from parents who gave their informed consent were included in the study. The same nurse inject vitamin K for all study sample to ensure validity of procedure was a bachelor degree pediatric nurse who had 15 years of experience handling neonates in the neonatal wards which makes him most suitable to perform the procedure ensuring the successfulness of the procedure, the intervention, and also guarantying the safety and avoiding any unnecessary injury to the neonate.

In the postnatal ward where the study was conducted, routine care (cleaning, drying, nasal care) is carried out under a radiant heater. Vitamin K is administered during the first few hours of life. The injection procedure protocol is provided in table (1). The newborn stays in the postnatal ward until they are actively feeding and shows no sign of distress then they are delivered to their mother / legal guardians (father, grandmother). All newborns receive vitamin K prophylaxis dose by IM method after birth for preventing hemorrhagic [16]. In this study, the newborn pain was evaluated by NIPS and Pain was evaluated at one time point during the IM injection procedure. In the study, neonates who received Z and A methods for IM injection were included in the experimental group, while those who received IM injection with the routine method were included in the control group. All interventions to the newborns in the study and control groups were performed under a radiant heater.

Table (1): Vitamin K intramuscular Injection Protocol

Performing hand hygiene and wearing nitrile gloves
Using 1 ml syringe to draw Vitamin K supplement 0.5ml
Using the left vastus lateralis muscle site for injection

Wiping Area cleansed with alcohol and allowed it to air-dry before needle insertion
Insertion angle is 90°
After needle insertion Aspiration is performed
Needle withdrawal at the same angle as insertion
Site not massaged after the injection
Data recorded: Another investigator assessed and recorded

The study groups

Z-track group

During the administration of the injection, the neonate in supine position, the position of his/her legs was normally flexed, and the Z-track technique was adopted when administer the injection. During injection, the skin was pulled laterally, and, thereby, the cutaneous and subcutaneous tissues were moved by approximately 1 to 2 cm. The researcher who injected the drug used the non-dominant hand to displace the cutaneous and subcutaneous tissues. A co-observer recorded the pain score after withdrawal of the needle on the neonatal clinical data form.

The Air-lock

In the ALT, the dose of medication that will be administered to the neonates is first drawn into the syringe, followed by 0.1 - 0.2 ml of air. During the injection administration, a bubble of air is inserted after the entire dosage of medication has been administered to the injection site [12]. An additional investigator recorded the pain score after withdrawal of the needle on the neonatal clinical data collecting form following each injection.

The control group

During the administration of the injection, the neonate in supine position, the position of his/her legs was normally flexed and the injection was administered using the routine method. During the routine injection technique practice, the skin was not pulled laterally. A co- observer (nurse) recorded the pain score on the neonatal clinical data form. Figure (1) shows the sample flowchart.

Ethical Considerations

The Scientific Research Committee approval (Approval number: 37 dated in 6/11/2024) was obtained from College of Nursing/ University of Baghdad.

Statistical Data Analysis

The statistical package for social sciences (SPSS) version 27 was used for statistical analysis. Categorical data were represented as numbers and percentages, and numerical data as mean and standard deviation. Normal distribution was tested using the Shapiro-Wilk test and graphical analyses. Mann Whitney *U* test was used for comparisons between two groups of non-normally distributed quantitative variables. Statistical significance was accepted to be $p < 0.05$.

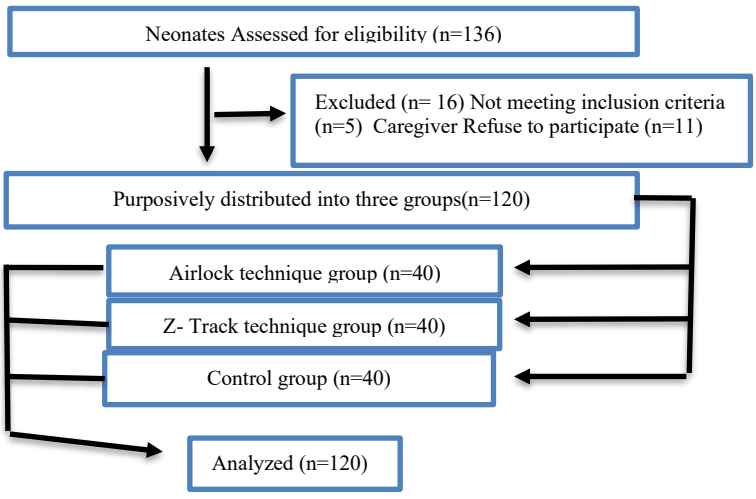

Figure (1): the sample flowchart

Results

Table (2): Distribution of demographic variables for neonates in the study and control groups

Demographic Variables	Categories	Study Groups			
		Air-lock technique N (%)	Z-track technique N (%)	Control group N (%)	Total N (%)
Gestational week	37 weeks	4(10.0%)	1(2.5%)	7(17.5%)	12 (10%)
	38 weeks	20(50.0%)	22(55.0%)	20(50.0%)	62 (51.7%)
	39 weeks	15(37.5%)	14(35.0%)	12(30.0%)	41 (34.2%)
	40 weeks	1(2.5%)	3(7.5%)	1(2.5%)	5 (4.2%)
	Total	40(100%)	40(100%)	40(100%)	120 (100%)
	Mean (SD)	38.33(.694)	38.48 (.679)	38.17(.747)	38.33 (0.712)
Sex	Male	18(45.0%)	24(60.0%)	19(47.5%)	61(50.8%)
	Female	22(55.0%)	16(40.0%)	21(52.5%)	59 (49.2%)
	Total	40(100%)	40(100%)	40(100%)	120 (100%)
Weight	Mean (SD)	2868.00 (265.660)	2947.50 (288.779)	2875.75 (255.753)	2897.08 (270.534)
Age (in hours)	Mean (SD)	1.40(.545)	1.38(.628)	1.35(.580)	1.38 (0.581)

N= frequency; **%**= percentage; **SD**= standard deviation

Table 2 shows the vitamin K study sample. Regarding gestational age, most of the sample had 38 weeks of gestation within the study and control groups (50.0%, 55.0, and 50.0%). Males were dominants in the Z-track group (60%), however females were the majority in the Airlock and control groups (55%, 52.5%). The mean birth weight for the airlock group (2868 g), the Z-track group (2947.5 g) and the control group (2875.75 g). The mean age for the neonates was 1.40(.545) in the AL, 1.38(.628) in the ZT, and1.35 (.580) in the control group.

Table 3: Total Mean Score of Newborn pain in Study and Control groups with Post- hoc Pairwise comparisons for neonates undergoing vitamin K injection

Descriptive statistics	NIPS score			Inferential Statistics		Post- hoc Pairwise Comparison		
	Air-lock technique	Z- track technique	Control Group	KW	P value	Group 1-2	Group 1-3	Group 2-3
Mean ± SD	3.65±1.14	3.28±1.26	4.53±1.08	21.38	**0.001****	Z: -9.75	**Z: -24.18**	**Z: -33.94**
Median (min-max)	4 (1-5)	3 (1-6)	5 (1-6)			P: .591	**P:0.005****	**P:0.001****

SD=standard deviation; **min**=minimum; **max**=maximum; **NIPS**=Neonatal infant Pain scale; **KW**= Kruskal Wallis test; p < 0.05* = significant; p < 0.01** = highly significant; **Z**= calculated using Mann-Whitney U test; **p**=probability value

Table 3 illustrates the total pain score for vitamin K injection and hepatitis B vaccination. The table demonstrates the mean pain score in the airlock technique group was (3.65) with a median of (4) on the pain scale, the Z-track technique group is (3.28) with a median of (3), and the pain scored (4.53) with a median of (5) among the control group. The table shows a statistically significant difference between the groups (KW=21.387, p=0.000). A post-hoc pairwise comparisons between study groups were calculated. The results show that the Z-track technique was the most

significant in pain reduction (Z= -33.94, P= 0.000) followed by the Air-lock technique (Z=-24.18, P=0.005) compared to the conventional method of IM injection.

Table 4: Pain level among neonates who received the interventions during Vitamin K injections

Outcome variable	Categories	Groups						Total	
		ALT Group		ZTT Group		Control group			
		N	%	N	%	N	%	N	%
NIPS	No/ mild pain	8	20.0%	12	24.5%	2	5.0%	21	17.5%
	Moderate pain	21	52.5%	20	50.5%	15	37.5%	57	47.5%
	Sever pain	11	27.5%	8	20.0%	23	57.5%	42	35.0%

N= frequency; %= percentage; mild pain= 1-2; moderate pain= 3-4, sever pain= >5 on pain scale

Table 4 illustrates the pain levels and leakage diameter between study and control groups. Moderate level of pain was observed to be dominant in the ALT and ZTT groups (52.5%, 50.5%) and most of neonates in the control group had severe pain (57.5%). As for the leakage diameter, mild leakage levels were noted to be dominant in the ZTT group (57.5%), and moderate leakage levels were the majority in the ALT group. However, the control group had the highest leakage levels among the three groups (57.5%).

Discussion

The current study showed data of neonates' gestational age, neonates of 38 weeks of gestation are considered dominant in the three groups for vitamin K sample. This finding is consistent with the results of the study conducted to assess the effectiveness of using distraction with breastfeeding to reduce vaccination pain in children, they found that the mean gestational week was 38.87 [18]. However, another study conducted to assess the oral sucrose effect on vaccination pain nurses. A study conducted on effectiveness of shot-blocker for painful immunization found that the mean gestational week was 39.58 [19]. From the research point of view, it can be explained that newborns are born through cesarean section are delivered before reaching 40 weeks of gestation.

The current study recorded data on the sex of neonates. Females constitute the majority at more than half in Airlock and control groups whereas males account for 60.0% in the Z-track group. A previous clinical trial conducted in Iran concerning the efficacy of vibration with cold applications on pain of vaccination found that the majority of the sample in the study and control groups are females [20]. Another trial conducted by Patel et al. in India regarding the effect of swaddling versus skin to skin for pain management of vitamin K injections found that most neonates were males in both the study and control groups [21].

Our study finding reveals that the mean weight for the vitamin k sample was 2897 for the three groups combined. Another study by Patel et al. reported that mean weight for neonates was 2730 grams in the control group and 2630 grams in the study group [21]. One other study conducted by Taghinejad et al., reported the mean weight for neonates was 3238.33 grams for the first study group, 3309.31 grams for the second study group, and 3263.33 grams for the control group [22]. A randomized study revealed that the mean weight of the three groups under study were 3435 grams in the first group, 3130 grams in the second group and 3340 grams in the third group [23]. From the point of view of the researcher this is due to the fact that neonates

that are healthy and near term have a birth weight range between 2500 grams -3500 gram.

Regarding age of neonates, it was recorded that majority of the study sample were aged respectively less than 2 hours during their participation in this study. Our finding differs from the results of a study reported by Rad et al. in Iran for the purpose of assessing the effects of inhalation of breast milk odor from the mother on pain response during hepatitis B vaccine in infants that found the majority of the sample were aged more than 24 hours during their participation in the study [24]. From the point of view of the researcher this result is due to the fact that all injections were performed respectively in the first 1-2 hours of postnatal life.

Pain and intramuscular injection

The findings of the present study showed in table (3) that the mean pain score among the vitamin K sample was the lowest in the Z-track technique group (3.28) followed by Airlock technique (3.65) and the control group pain score was 4.53 and this difference in the mean pain score was of statistical significance as noted with Kruskal Wallis test of non-parametric independent samples (KW=21.38 at p value= 0.000) which called for the need of inter groups comparisons.

When comparing the Z-track technique to the Air-lock technique, there was no statistical differences between the two groups. However, when comparing the Z-track technique with the standard technique, there was a significant difference in the pain score indicating that the Z-technique yielded low pain score than the conventional method. On the other hand, comparing the Air-lock technique with the standard technique statistical differences were observed between the two groups indicating that the mean pain score was lower in the Air-lock group than the control group.

Henceforth multiple comparisons in table (3) indicated that the Z-track technique was more effective than the Air-lock and standard technique with a significant mean difference which was of a statistical significance. On the contrary, no statistical differences were evident in the pain score between the Air-lock and standard techniques of intramuscular injections.

This result was agreed upon by a study done by Bankston et al., on practices during intramuscular injections among American nurses that found out the process of using the Z-track method and the Air-lock method significantly reduces pain scores among mental health patients receiving anti-psychotic medications [25]. This result is supported by studies done by Fang et al. that evaluated the usage of the Z-track technique combined with lidocaine for painful injections of penicillin for primary syphilis patients. The study concluded that the combined technique is effective in reducing pain of intramuscular injections [26]. In a literature review that compare between the Z-track and Air-bubble techniques that are used in nursing practice during intramuscular injections procedures. The study found that the evidence in the previous literature supports the use of the two methods in pain reduction [27]. Also, Tambunan et al. approved on our results in their study conducted to assess the effects of z-track airlock techniques on intramuscular injections in adult patients [28]. Yilmaz et al. provided evidence on the use of the Airlock technique during IM injections, the study concluded that the technique is effective in reducing IM injections associated pain [29].

In addition to another study by Ayinde et al. that reviewing various non-pharmacological techniques found that one study conducted in the USA that was using

the z- track technique and compared to the standard method of injection yielded low pain score among the study group samples [30]. Another study included the use of the Air-lock technique during subcutaneous heparin injections found that less pain was documented among those who received the intervention of Airlock technique compared to the conventional method [31]. However, results from one study conducted in Indonesia that included the Airlock and the Z-track techniques during neurobion vitamin injections in women concluded that no significant differenced were found between the three groups in terms of pain scores [32]. According to another study done by Ling Lin et al. in Taiwan that was not in-line with our finding. The study compared pain levels among anti-psychotic's injections using three techniques, one was the z-technique, the second was the Airlock technique, and the third was combination of the two techniques. The results of the study showed no statistical differences among the three groups in 5 minutes post injection and 30 minutes post injections [33]. This difference due to variations in patient age, medication type, and pain measurement methods.

The research hypotheses (H_1) approved that implies (Neonates receiving intramuscular injections using the airlock and/or Z-track techniques experience significantly less pain than those receiving standard technique.)

Limitations

Considering the study took place in one postnatal ward, so the results are limited to those neonates only. Another limitation is that the study did not include hepatitis B vaccine injection. The study included only term infants limited to vitamin K injections.

Conclusion

In the study, the researchers have reached that Z- track and the Air-lock techniques application during IM injections for neonates had an alleviating effect on the pain. Mean pain levels scores in the Z-Track Therefore, this strategy for pain reduction can be utilized by nurses during standard injection practice and is considered cost-effective during intramuscular injections of neonates.

Recommendations

Establishing educational programs and practice training for nursing staff in Iraq hospitals about the Z-track and Airlock techniques improve their knowledge and skill regarding application of the techniques in practice. The study can include neonates undergoing vaccination such as Hepatitis B vaccine birth dose. The effectiveness of Z-track technique can be compared with the Air-lock technique for neonatal injection. Future similar studies can be conducted on older children during pentavalent vaccination, and medications administered muscularly for ill patients.

Conflicts of interest

The authors declare that there is no conflict of interests regarding the publication of this review article.

Ethical Approval

The authors state that their systematic literature review did not require ethical approval. This research is based on a doctoral dissertation, adhering to established protocols.

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Author contribution

HJK designed, conducted, and analyzed the study, and drafted the manuscript. ZWA supervised the research and provided critical review.

Data availability statement

The data that support the findings of this study are available from the authors, but restrictions apply to the availability of these data, which were used under license for the current study and are not publicly available. However, the data can be obtained from the

authors upon reasonable request and with appropriate permissions.

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