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Effect Of Prothrombin Complex Concentrate In Non-Operative Management For Treatment Of Severe Traumatic Intra-Peritoneal Abdominal Hematoma

Mohamed Gaber Ibrahim Mostafa Allam[1], Atef A. Alfeky[1], Mahmoud Gaballah Montaser[2], Ayman Salah Emara Abouelnour[3], Abdelkarem Hussiny Ismail Elsayed[3], Mohamed A. Elbadawy[3], Mohamed Alshahat Elsayed Ali[3], Mohamed Mohamed Hegab[3], Mohamed Hassan Mohamed Arafa[3], Hazem Abdallah Ali[3], Ahmed Maher Abouelnasr Khalifa[3], Emad Abd Elhaliem Abd Elsalam Mahmoud[3], Tarek Abualkasem Abualwafa Mohammed[3], Mahmoud Elsayed Abdelmawla Elsayed[3], Alaa Abdelraouf Taha Hassan[3], Mohammed Ezzelarab[3], Ahmed R. I. Ali[3], Hany Said Ismail Ramadan[3], Reda Ramadan Hussein Yousef[4], Shaimaa Ramadan Barakat[5], Omaima Ahmed Elsayed Hamed[6], Mohammed El Sayed Abdel Hameed[1], Ihab Anwar Orabi[7], Eman Gabr S. Hemaidah[8], Anas Fawzy Khalil[3], Ahmed Gamal Salah Elsawy[3]

[1]Department of Anesthesia, Faculty of Medicine, Ain Shams University, Cairo, Egypt
[2]Assisstant Professor of Anesthesiology, Intensive Care and Pain Medicine, Damietta Faculty of Medicine, Al-Azhar University, Egypt.
[3]Department of Anesthesia, Intensive Care and Pain Management, Faculty of Medicine, Al-Azhar University, Cairo, Egypt
[4]Department of Radiology- faculty of medicine – Al-Azhar university- Cairo- Egypt
[5]Department of Radiology- faculty of medicine for girls – Al-Azhar university- Cairo- Egypt
[6]Department of Laboratory -National Heart Institute-General Organization for Teaching hospitals and Institutes, Egypt.
[7]Department of Internal Medicine, Faculty of Medicine, Suez Canal University, Egypt
[8]Associate Professor of Anesthesiology and Critical care, Department of Anesthesia, Intensive Care, and pain management, Faculty of Medicine For girls Al-Azhar University, Cairo, Egypt

ABSTRACT

Background: Non-operative management (NOM) is increasingly used in selected severe abdominal trauma cases, with success rates of 80%–90%. The role of imaging as X ray and focused Assessment with Sonography for Trauma (FAST) serves as the initial bedside screening modality. CT is essential for selecting appropriate candidates, assessing injury severity, detecting active bleeding, and monitoring for complications during NOM. Adjuncts such as prothrombin complex concentrate may further support successful conservative treatment

Objective: This study aimed to evaluate the effect of Prothrombin Complex Concentrates (PCCs) on limiting the expansion of intraperitoneal hemorrhage after severe abdominal trauma, stabilizing hemoglobin levels, reducing intra-abdominal pressure, and improving tissue perfusion and coagulation profiles in ICU patients. Imaging, particularly contrast-enhanced CT, was essential for quantifying hemorrhage extent, monitoring hematoma progression, and assessing the therapeutic response to PCCs.

Methods: This prospective, double-blinded, randomized controlled study enrolled 80 patients with severe traumatic massive hemoperitoneum. Patients were randomly allocated to either group A(n=40), received our standard protocol of resuscitation or group B (n=40) received our standard protocol of resuscitation with administration of PCC. Size of intra-peritoneal hematoma, hemoglobin level, intra-abdominal pressure, daily urine output, arterial blood gases and coagulation profile were monitored daily. Also, number of patients discharged at the end of studied period was monitored.

Results: Patients in Group B exhibited a significantly decrease in the size of intra-peritoneal hematoma, exhibited stabilization in hemoglobin level, decreasing in the intra-abdominal pressure, restored normal tissue perfusion and coagulation profile. And higher rate of discharge at the end of the studied period.

Conclusion: this study clarifies the effect of PCC in controlling intra-peritoneal hematoma following abdominal trauma, stabilizing hemoglobin level, decreasing intra-abdominal pressure, restoring normal tissue perfusion and coagulation profile between patients with severe traumatic intra-peritoneal hematoma. And also increase rate of discharge from ICU between those patients. Imaging, primarily contrast-enhanced CT, played a crucial role in objectively assessing hematoma size, monitoring interval changes, and evaluating the therapeutic response to PCCs, thereby guiding clinical decision-making throughout patient management.

KEYWORDS: Prothrombin, Concentrate, Non-operative, Traumatic, Hematoma, ICU..

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INTRODUCTION

The strategy of severe abdominal injury management is completely changed from the era of immediate surgical exploration to strictly follow selective non-operative management strategy (NOM). At present, NOM is the standard treatment for an abdominal trauma patient (after exclusion of any intra-abdominal organ damage or any intestinal perforation). NOM can reduce the rate of non-therapeutic abdominal exploration and has been introduced as the safest choice in the experienced centers which equipped with available surgeons, operating rooms, intensive care units, and other supporting resources. [1-2] Augmentation of coagulation profile of those patients considered corner stone in NOM strategy. PCC have been introduced for the management of major life-threatening bleeding and coagulopathy after severe life-threatening abdominal trauma it can be considered as a major pillar in NOM strategy. [3-5] PCCs contain vitamin K-dependent clotting factors (II, VII, IX, and X) and are traditionally used for emergency reversal of vitamin K antagonists in major hemorrhage [6]. The products are either 3- or 4-factors PCC (3F, 4F-PCC) formulations depending on the concentrations of Factor VII [7]. Compared to FFP, PCC has a long shelf-life at room temperature and therefore can be available rapidly for treating clinicians both in-hospital and prehospital settings. It contains a high, supra-physiological concentration of clotting factors and is administered in small volumes. However, the effectiveness of PCCs as a treatment for severe nonsurgical intra-peritoneal hematoma remains uncertain. [8-10]

Moreover, it is unclear as to whether PCCs are a safe alternative to the traditional ways of resuscitation (fresh blood and FFP) in the early or later phases of major hemorrhage management, with an increased thrombosis risk in patients who are themselves in a pro-coagulant phase post-traumatic abdominal injury [8-10].

Imaging plays a fundamental and indispensable role in the assessment and management of severe traumatic intraperitoneal abdominal hematoma, with the choice of modality determined primarily by the patient's hemodynamic status. The initial objective of imaging is the rapid detection of intraperitoneal free fluid—presumed to represent hemorrhage in the trauma setting—and the identification of immediately life-threatening injuries. X ray and FAST serves as the initial bedside screening modality in most trauma scenarios due to its rapidity, non-invasive nature, portability, and absence of ionizing radiation, allowing its use during active resuscitation. FAST demonstrates high sensitivity for detecting clinically significant hemoperitoneum, with sensitivity approaching 100% in hypotensive patients, and a positive FAST in a hemodynamically unstable patient constitutes a strong indication for immediate exploratory laparotomy, thereby obviating the need for further imaging in order to expedite hemorrhage control. In contrast, hemodynamically stable patients, or those who respond favorably to initial resuscitation, are best evaluated with contrast-enhanced Computed Tomography (CT), which is considered the definitive diagnostic modality. CT provides detailed anatomical characterization that enables precise localization of the injured organ or vascular structure, accurate grading of solid organ injuries, and detection of active bleeding through the identification of contrast extravasation, particularly when progressive on delayed imaging—a finding that may necessitate urgent surgical or angiographic intervention. Additionally, CT facilitates comprehensive evaluation of associated traumatic injuries, including bowel perforation, retroperitoneal hematomas, and skeletal injuries, which frequently accompany severe abdominal trauma (24 - 26).

OBJECTIVE

Study Design and Setting: This prospective, double-blinded, randomized controlled study was conducted in the Anesthesia, Intensive Care, and Pain Management Department at Al-Azhar University Hospitals. Ethical approval was obtained from the Institutional Review Board (IRB), and the study was registered at ClinicalTrials.gov (469/2025)

Study Population: A total of 80 patients admitted to our surgical ICU with severe traumatic massive hemoperitoneum diagnosed by ultrasound scoring of hemo-peritonium and confirmed by CT abdomen with contrast were enrolled. Inclusion criteria were: Patient acceptance**,** adult (Age: ≥21 and ≤65 years old) abdominal trauma with massive non-surgical hemo-peritonium either with or without other injuries, and both sexes (males or females).

Exclusion criteria included:

- Any patient with deranged coagulation problems either acquired or congenital involving his platelets or clotting factors.
- Patients with advanced hepatic, renal, cardiovascular, or respiratory diseases.
- Patients with a history of cardiac arrest or anoxic brain injury.
- Advanced malignancy.
-

Randomization and blinding: Patients were randomized into two groups (n=40 each). Neither the medical team, injector team nor the data collection team was aware of the treatment allocation.

Intervention:

•Group A (Control): Standard resuscitation care according to our hospital protocol (explained in details later), in the form of fluid, blood, blood product resuscitation to control the bleeding.

•Group B (PPC Group): Standard resuscitation care according to our hospital protocol, and the previous mentioned procedures with administration of PPC [Kcentra® (CSL Behring, Germany)] slowly intravenous

Outcome Measures:

- **Primary Outcome:** decreasing of the size of intraperitoneal hematoma, stability of Hemoglobin concentration, decreasing the intra-abdominal pressure, restoring normal tissue perfusion and restoring normal coagulation profile between those patients.
- **Secondary Outcome:** Length of ICU stay and proportion of patients successfully discharged.

MATERIAL AND METHODS

Sample size:

Depending of the previous study and on the annual statistics given to the authors by the community department of our hospital about the annual incidence of surgical ICU admission for cases selected in this study, 50 patients were sufficient to produce significant statistical data.

All Cases Underwent:

Patient Examination and investigation:

All patients were hospitalized and admitted to surgical ICU, full history with physical examination including GCS and routine investigations (complete blood count (CBC), Coagulation profile, sepsis screen, liver and kidney function testes) and Vital data monitoring including core temperature were done daily. All radiological study (X-ray, US, CT) and all consultations needed (as Anesthesiology, ICU, surgical, neurosurgical, orthopedic or cardiothoracic consultations) were done. Resuscitation was done according to our hospital policy of massive blood transfusion and including blood, blood products and fluid. Our end point of resuscitation was [Mean arterial blood pressure $\geq$60 mmHg, Hemoglobin (Hb) $\geq$10 gm %, urine output (UOP) was 0.5 ml /kg /hour, platelets $\geq$100.000 cm^3, INR $\leq$ 1.5, PT $\leq$14 second and PTT $\leq$ 45 second and arterial blood gases shows PH $\geq$7.35, hypoxic index $\geq$ 400, PCO2 $\leq$ 45 and HCO3 $\geq$ 20 mmol/L]. ETT intubation and inotropes used if needed. The diagnosis of massive intraperitoneal hematoma done clinically by medical and surgical team and radiologically by Computerized tomography with intravenous contrast and ultrasound abdomen. in our study blood should involve all spaces in the peritoneum to be massive. Also, it is important to exclude all surgical causes of intra-peritoneal hematoma (any organ damage, intestinal perforation and/or arterial cause of this massive intra-peritoneal hematoma). All patients received cefazolin as prophylactic chemotherapy 50mg/kg intravenous per day and the dose divided and given every 8 hours for 3 days. The duration of the study was 3 days. Any patient not improved within this period excluded from our results.

For all patients in both groups: Urine output (UOP)collected daily, Arterial blood gases done every 8 hours and coagulation profile done daily.

In our study a satisfactory term given to UOP daily if rate of UOP is 0.5 ml /kg /hour, given to coagulation profile daily if platelets $\geq$100.000 cm^3, INR $\leq$ 1.5, PT $\leq$14 second and PTT $\leq$ 45 and given to arterial blood gases daily if PH $\geq$7.35, hypoxic index $\geq$ 400, PCO2 $\leq$ 45 and HCO3 $\geq$ 20 mmol/L done every 8 hours/day. If any result from the 3 ABG done daily for all patients not fulfilling the previous mentioned parameters before, so it was excluded and not recorded as satisfactory ABG in that day. A satisfactory tissue perfusion term given in our study if both UOP and ABG were satisfactory according to the criteria mentioned before.

All the former data recorded and presented daily during the studied period.

Method of sample collection:

patients were randomly allocated by a computer - generated table into two groups, each group of (40 patients). For all patients in both groups a daily routine investigation done according to protocol of our hospital including complete blood picture including hemoglobin concentration, coagulation profile and platelets count, arterial blood gases, daily abdominal ultrasound done by the same operator for evaluation of the size of intra peritoneal hematoma to minimize the subjective error, daily assessment of intra-abdominal pressure by 3- way folly catheter.

Control group (group A) (n= 40): received the resuscitation according to our hospital protocol of massive blood transfusion until we achieved Hb $\geq$ 10 gm%, Coagulation profile within normal, MAP (mean arterial blood pressure within $\geq$60 mmHg, CVP 8-12mmHg and urine output $\geq$0.5 ml /kg /hour. plus 150 ml dextrose 5% solution over 15 min. Intravenous infusion during resuscitation.

PCC group (group B) (n= 40): received the same resuscitation protocol as group A but they receive PCC Kcentra® (CSL Behring, Germany) during resuscitation in dose of 35mg/kg in 150 ml dextrose 5% solution over 15 min. Intravenous infusion.

Withdrawal Criteria: patients have the right to withdraw from the study at any time without any negative consequence on their medical treatment plan.

Operational design:

Patients selected from Al-Azhar University Hospitals who admitted to ICU with massive non-surgical intraperitoneal hematoma followed severe abdominal trauma, diagnosed clinically and by Computerized tomography with intravenous contrast and ultrasound abdomen.

Clinical Data monitored and methods of its presentation:

Data of the primary outcome include size of the intra-peritoneal hematoma, Hemoglobin level intra-abdominal pressure, daily urine output, ABG every 8hours and coagulation profile recorded for all patients in both groups on daily basis and presented in

tables numerically and by percent. The secondary outcome data includes number of patients discharged from the ICU presented once by the same way mentioned before but at the end of the studied period.

RESULTS

A total of 80 patients admitted to our surgical ICU with massive non-surgical intra-peritoneal hematoma diagnosed by clinically, abdominal ultrasound and by abdominal computerized tomography with contrast their demographic data presented in table (1)

Patient Characteristics: There were no statistically significant differences between groups in terms of baseline demographic and clinical characteristics.

Primary Outcome:

- A significantly higher percentage of patients in Group B who showed decreasing size of intra-peritoneal hematoma, stable hemoglobin level, lower intra-abdominal pressure, restoring normal tissue perfusion and normal coagulation profile compared to Group A ($p<0.05$).

Secondary Outcome:

- Group B had a significantly higher percentage of patients discharged from the ICU within the study period ($p<0.05$).
- 21 patients discharged by the surgical team from group A at the end of the studied period from them only 13 patients could be discharged by ICU team, while 8 patient's ICU team hold their transfer due to unstable hemoglobin level with increase abdominal pressure. On the other hand, 22 patients discharged by the surgical team from group B at the end of the studied period all of them could be discharged by ICU team. All data expressed numerical and by percent on the tables 1,2,3,4,5 and 6.
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Table (1) shows the demographic data of the studied patient's groups

	Group A (n=40)		Group B (n=40)		P value
Age Group	No	%	NO	%	
≥21 - <45 years	21	52.5%	22	55%	0.84
45 - ≤65 years	19	47.5%	18	45%	
Sex					
Male	26	65%	27	67.5%	0.81
Female	14	35%	13	32.5%	

Table (2) shows Ultrasound assessment of the hematoma

	Group A (n=40)		Group B (n=40)		P value
1st Day	No	%	No	%	
Decreasing/ Same size	2	5%	34	85%	< 0.0001
≤10% increase	20	50%	4	10%	< 0.0001
11-20% increase	10	25%	2	5%	< 0.0001
>20%increase	8	20%	0	0%	< 0.0001
2ndDay					
Decreasing/ Same size	9	22.5%	38	95%	< 0.0001
≤10% increase	18	45%	2	5%	< 0.0001
11-20% increase	9	22.5%	0	0%	< 0.0001
>20%increase	4	10%	0	0%	< 0.0001
3rd Day					
Decreasing/ Same size	17	42.5%	40	100%	< 0.0001
≤10% increase	14	35%	0	0%	< 0.0001
11-20% increase	9	22.5%	0	0%	< 0.0001
>20%increase	0	0%	0	0%	< 0.0001

Table (3) shows hemoglobin level of all patients in the studied period

	Group A (n=40)		Group B (n=40)		P value
1stDay	No	%	NO	%	
Same/increase	3	7.5%	30	75%	< 0.0001
10%≥decrease	19	47.5%	6	15%	< 0.0001
11-20% decrease	9	22.5%	4	10%	< 0.0001
>20% decrease	9	22.5%	0	0%	< 0.0001
2nd Day					
Same/increase	8	20%	36	90%	< 0.0001
10≥decrease	20	50%	4	10%	< 0.0001

11-20% decrease	9	22.5%	0	0%	< 0.0001
>20% decrease	3	7.5%	0		< 0.0001
3rd Day					
Same/increase	18	45%	40	100%	< 0.0001
10%≥decrease	13	32.5%	0	0%	< 0.0001
11-20% decrease	9	22.5%	0	0%	< 0.0001
>20% decrease	0	0%	0	0%	< 0.0001

Table (4) shows the intra-abdominal pressure recorded for all patients during the studied period

Pr. In mmHg	Group A (n=40)		Group B (n=40)		P value
1stDay					
<12	11	27.5%	36	90%	< 0.0001
12-20	20	50%	4	10%	< 0.0001
>20	9	22.5%	0	0%	< 0.0001
2nd Day					
<12	19	47.5%	39	97.5%	< 0.0001
12-20	19	47.5%	1	2.5%	< 0.0001
>20	2	5%	0	0%	< 0.0001
3rd Day					
<12	26	65%	40	100%	< 0.0001
12-20	14	35%	0	0%	< 0.0001
>20	0	0%	0	0%	< 0.0001

Table (5) shows UOP, ABG and coagulation profile recorded for all patients during the studied period

	Group A (n=40)		Group B (n=40)		P value
1stDay	No	%	No	%	
Satisfactory UOP/day	4	10%	24	60%	< 0.0001
Satisfactory ABG	5	12.5%	23	57.5%	< 0.0001
Satisfactory coag. profile	3	7.5%	23	57.5%	< 0.0001
2nd Day					
Satisfactory UOP/day	11	27.5%	30	75%	< 0.0001
Satisfactory ABG	10	10%	31	77.5%	< 0.0001
Satisfactory coag. profile	9	22.5%	32	80%	< 0.0001
3rd Day					
Satisfactory UOP/day	18	45%	39	97.5%	< 0.0001
Satisfactory ABG	20	50%	38	95%	< 0.0001
Satisfactory coag. profile	19	47.5%	40	100%	< 0.0001

UOP: urine output, coag: coagulation profile ABG arterial blood gases

Table (6) shows number of patients discharged at the end of the studied period

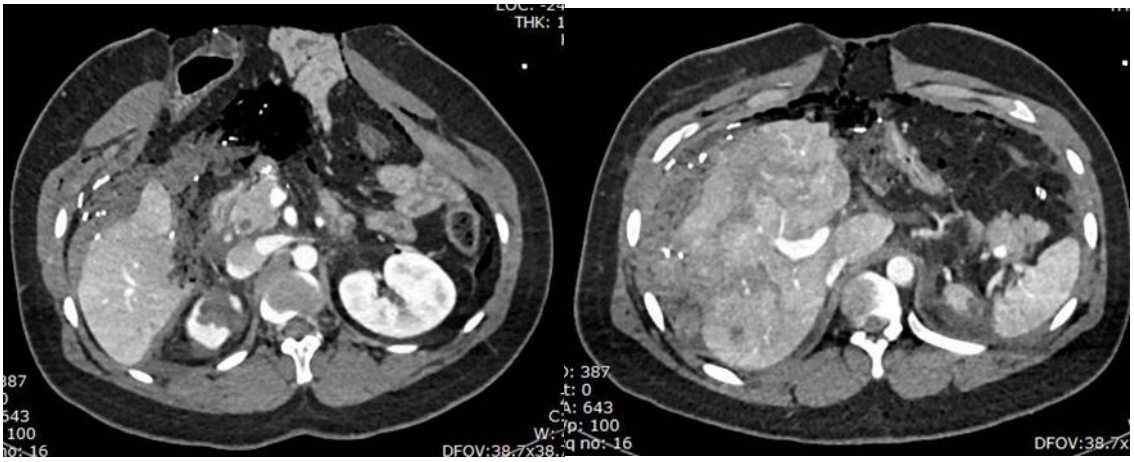
	Group A (n=40)		Group B (n=40)	
	No	%	No	%
Number of discharged patients by surgery team	21	----	22	---
Number of discharged patients by ICU team	13	61.9%	22	100%

DISCUSSION

Emergency imaging should be done for rapid diagnosis of life-threatening injuries allowing simultaneous evaluation and resuscitation. Subsequent comprehensive imaging is essential to diagnose the often clinically missed injuries to reduce the overall morbidity (25).

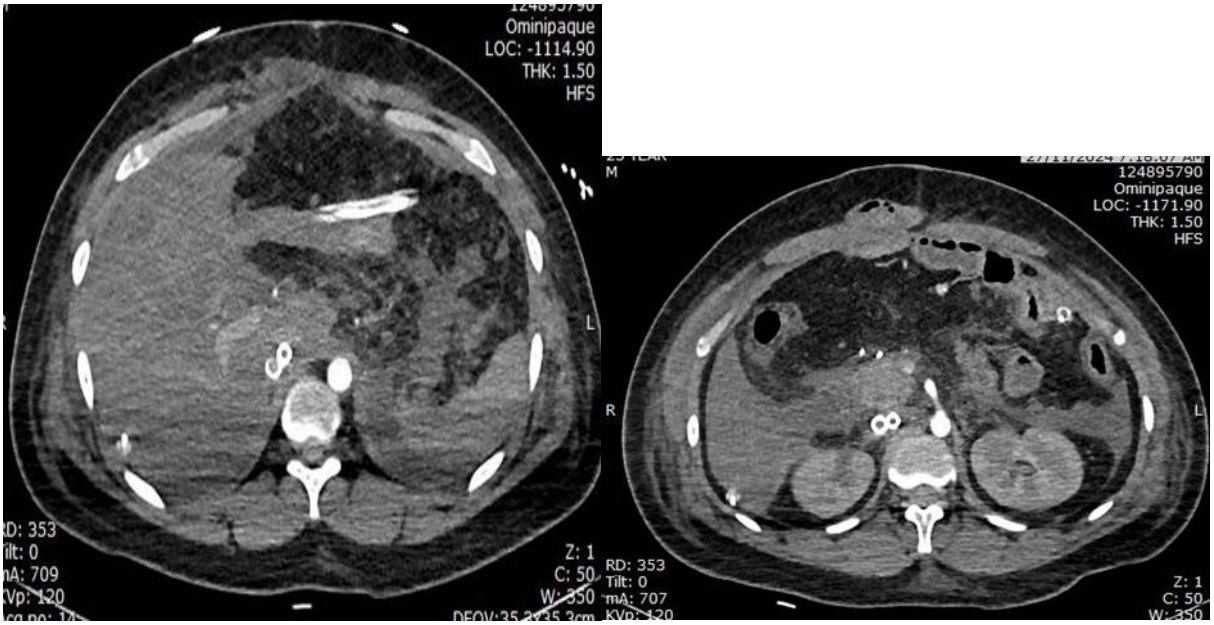
Organ injury can be easily diagnosed by abdominal ultrasound as well as the presence of free intra-abdominal fluid, which could be blood or intestinal secretions, that provides indirect evidence of these injuries. X ray and ultrasound are non-invasive, portable, US using no ionizing radiation, repeatable, and easily performed in the emergency unit, at the same time with resuscitation methods. FAST is a fast examination method that could demonstrate intraperitoneal fluid. Several studies found this technique to be sensitive (79–100%) and specific (95.6–100%), particularly in hemodynamically unstable patients (27). Our study found FAST to be 93% sensitive and 99% specific.

Contrast enhanced computed tomography (CT) is the radiological golden standard for abdominal visceral injuries, provides detailed anatomical characterization, accurate grading of solid organ injuries, and detection of active bleeding. Additionally, CT facilitates comprehensive evaluation of associated traumatic injuries (26). CT mainly used for measurement of the hematoma size initially and in follow up to monitor the interval regression and response to treatment. (Figures 1-5)



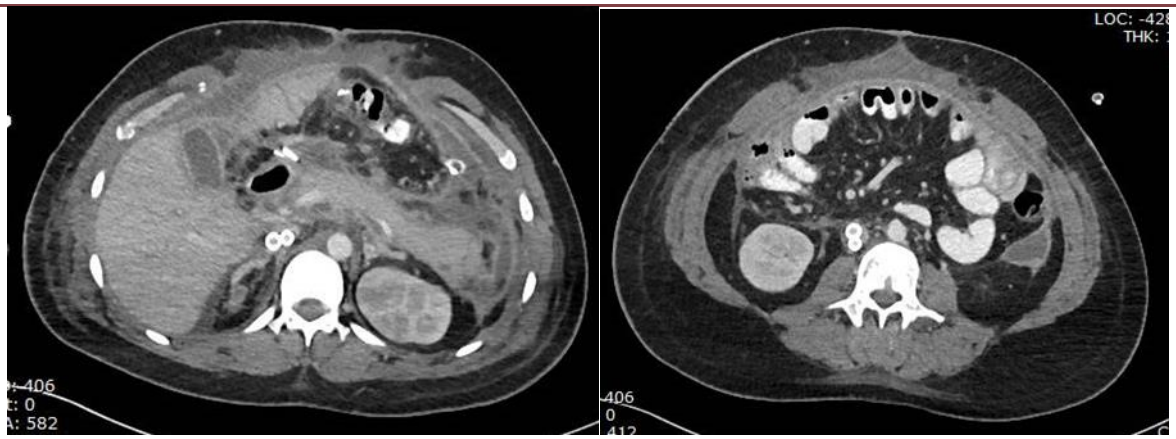
A B

Fig. 1: A, B: Axial enhanced CT scan of the abdomen shows liver lacerations seen as non-enhanced hypodensity, no evidence of contrast blush. Retroperitoneal and mesenteric fat stranding, abdominal wall defect and pneumoperitoneum. Perihepatic collection of 240.0 ml.



A B

Fig.2: A, B: Follow up Contrast enhanced CT after 3 days shows abdominal drain, right subpherinic and echmo catheter in IVC. Regression of peri hepatic collections measuring about 30.0 ml, and perisplenic collection about 135.0 ml.



A B

Fig.3: A, B, : Contrast enhanced CT scan 4 weeks later shows reduced perisplenic collection measuring 54.0 ml, perihepatic collection about 30.0 ml, and left para colic collection measures 45.0 ml.

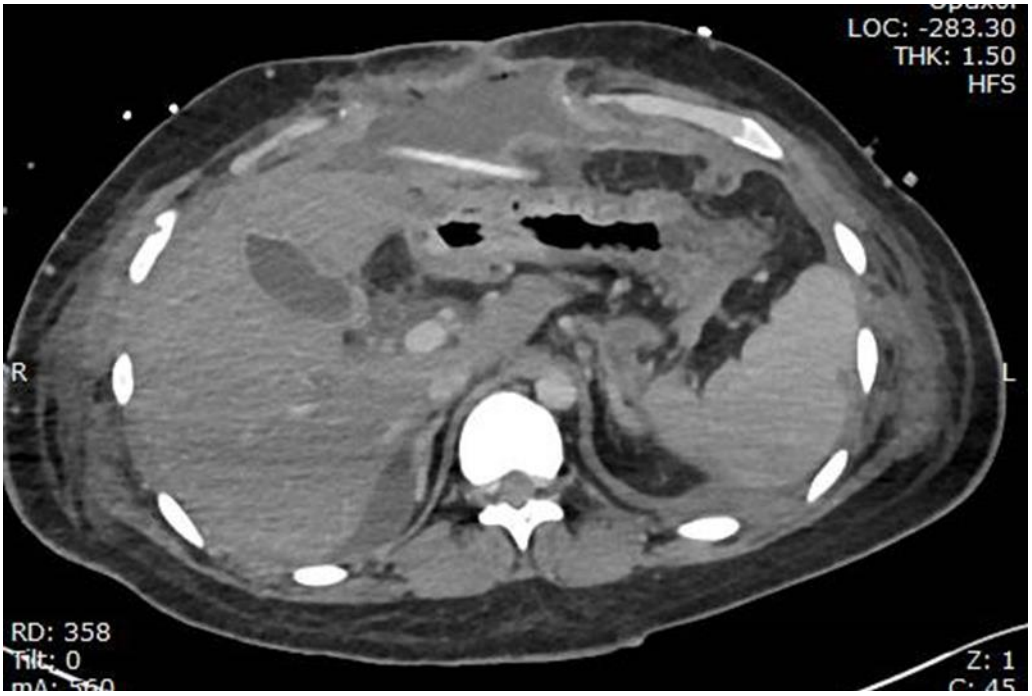


Fig. 4: Contrast enhanced CT scan one week later shows omental collection about 110.0 ml. Regression of other collections.

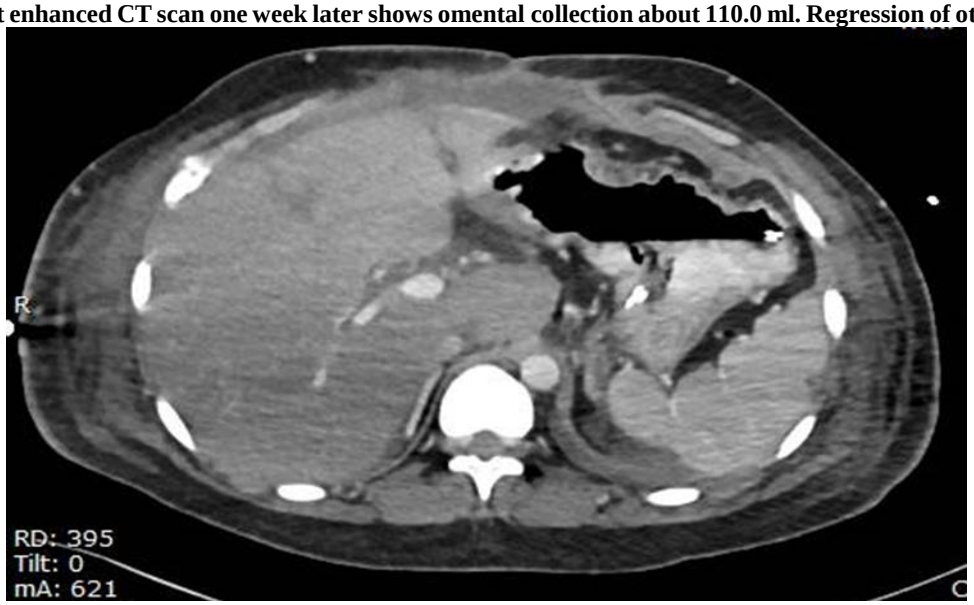


Fig. 5. Contrast enhanced CT scan 10 days later shows regression of all collection, only traces of fluid were noted.

This study demonstrates that the administration of Prothrombin Complex Concentrate (PCC) is an effective and rapid method for controlling severe massive intra-peritoneal bleeding in NOM strategy. PCC group showed a significant reduction in both, size of the intraperitoneal hematoma, intra-abdominal pressure. Also, PCC group showed significant higher number of patients who had stabilization in hemoglobin level, normal tissue perfusion and normal coagulation profile. With higher rate of discharge from ICU following severe intra-peritoneal hematoma. There was no significant difference found between demographic data of patients of both groups. Duration of the study was three consecutive days this duration decided by our research and community department of our hospital and by our research team who reviewed the previous published studies in this issue. Number of patients decided by reviewing our hospital annual statistics and number of cases admitted with severe massive intra-peritoneal bleeding per year and also approved by research and community department of our hospital.

Aligning with previous research that has established its superiority over fresh frozen plasma (FFP) in terms of both efficacy and safety. The unique rapid action of PCC by providing patients with immediate vitamin K dependent factors (II, VII, IX, X) with addition of protein C and S put the patients in safe zone from profound bleeding due to coagulopathy induced by massive traumatic bleeding. [10-12] It augments both intrinsic and extrinsic pathway of coagulation and thus leading to a stable fibrin clot which difficult to be lysed by fibrinolytic system. Its pharmacokinetic action being rapid stable component with 8 hours' duration of action enable it to rapidly control severe life-threatening bleeding especially traumatic bleeding. More over the presence of protein C and protein S limits its thrombotic formation and reduce thrombotic complications compared to FFP. [13] It can be considered as replacement treatment in trauma patient who always complain from deficiency of vitamin K dependent factors in stress and trauma, as in stress and due to decrease hepatic blood flow or shocked liver the replacement of vitamin K dependent factor from liver to plasma get slower than usual. Moreover, it replaces factor VII which has half-life of only 6 hours. [14] And intuitive factor VII is essential factor in extrinsic pathway of coagulation. It also a stables molecule with preservation of its action for 36 months from the date of manufacture compared to FFP with very short half-life (2-6 hours) and need frozen chain of preservation during this period. [15]

Additionally, we observed that PCC administration was associated with reduced transfusion-related complications, including volume overload, which is a known limitation of FFP. Especially in patients who had severe traumatic cardiac contusion or marked renal impairment. However, the variability in response among patients suggests that individualized dosing strategies may be necessary to optimize outcomes.

Another very important point was observed that this drug achieved marked success in controlling the **local complications** of the massive intra-abdominal hematoma which is compartmental syndrome as the decrease in the size of intra-peritoneal hematoma was going directly with decrease in the intra-abdominal pressure recorded in our study by 3-way folly catheter. This might put the most important cause of significant higher number of patients in group B who maintained satisfactory urine output and maintaining well perfused kidney all over the studied period. As regard controlling the **systemic complications** of the massive intra-abdominal hematoma, PCC could restore normal tissue perfusion between patients of group B in very short time this could be proved by significant higher number of patients in group B who had normal UOP, normal ABG which used as marker of tissue perfusion in our study. Moreover, we can say that PCC also protect patients of group B from one of the most common complication of massive blood transfusion which is disseminating intravascular coagulopathy (DIC) as there was a significant higher number of patients in group B who had normal coagulation profile and platelets $\geq$ 100.000cm^3 this could be explained physiologically by either rapid control of the hematoma size which through the fibrinolytic mechanism of patients bodies could lead to DIC or PCC lowering the numbers of blood and blood product given to the patient to restore coagulation profile and to keep patients hemoglobin $\geq$ 10 gm% or by both mechanisms together.

Lastly, according to our protocol of discharge from ICU, patients should be released from the care of surgical team first then ICU team applies the criteria of discharge from ICU on those patients. We observed that from the 21 patients in group A released from care of the surgical team due to retracted intra-peritoneal hematoma size and normalization of intra-abdominal pressure, only 13 patient fulfilled the criteria of discharge from the ICU and the rest their transfer was hold due to either their hemoglobin was <10gm%, deranged coagulation profile (not fulfilling the previous mentioned criteria), UOP was not adequate (not fulfilling the previous mentioned criteria), or ABG not fulfilling the previous mentioned criteria, While 22 patients in group B discharged from the surgical team due to the same causes mentioned before, all of them discharged from the ICU with significant higher rate of discharge from ICU between PCC group. This might be due to PPC achieved marked success in controlling the local complications and systemic complication as we explained in details before.

Comparison with Existing Literature

Our findings are consistent with those of previous studies, which have reported rapid INR normalization with PCC compared to FFP. For instance, a systematic review [16] highlighted that PCC achieves hemostasis more effectively, with fewer adverse effects related to volume overload. Furthermore, the use of four-factor PCC has been shown to be superior to three-factor PCC due to the inclusion of Factor VII, which plays a critical role in clot formation. Also, its short half-life (mentioned before) make it always need to be replaced in stress and severe traumatic bleeding.in this meta-analysis significant reduction in the mortality rate was found between patients given PCC while other authors contribute this reduction in the mortality to the use of FFP as co-treatment in these studies. [17,18,19,20,21]

However, discrepancies exist regarding thrombotic risk. Some studies suggest an increased incidence of thromboembolic events with PCC. Incidence of VTE was 35% in the PCC treatment arm compared to placebo (24%) in the randomized control studies. [22] Other studies have found rates of VTE from 3 to 15% following routine screening. The recent PROCOAG RCT emphasized

this possibility, where it is likely that patients without thrombin generation deficit received PCC, exposing them to a thrombotic risk, while they were unlikely to benefit from the intervention [23].

Clinical Implications

The rapid and effective reversal of anticoagulation with PCC makes it a valuable option in emergency settings, such as major trauma especially which associated with life threatening bleeding. Additionally, its role in perioperative management for patients requiring urgent surgery is noteworthy. The reduced need for large-volume fluid resuscitation further supports PCC as the preferred choice over FFP, particularly in patients at risk for cardiac decompensation.

Given the cost and limited availability of PCC, future guidelines should focus on refining indications and developing protocols for targeted administration to ensure cost-effectiveness without compromising patient outcomes.

LIMITATIONS AND FUTURE DIRECTIONS

Despite its strengths, this study has several limitations. First, the sample size was relatively small, which may limit the generalizability of our findings. Second, thromboembolic complications were not assessed in our study as our patients selected in emergency life threatening conditions so main goal during this stressful condition was to control bleeding and save patients life. Third, the study design did not allow for direct comparison between different PCC formulations, which could provide further insights into optimizing therapeutic strategies. Fourth, the use of CT imaging has inherent limitations: it requires patient transfer to the CT unit, exposes patients to ionizing radiation, and may be contraindicated in cases of renal failure or prior anaphylactic reactions to contrast material. Moreover, patients in pain or with altered consciousness may be unable to cooperate or assume optimal positioning, and the presence of medical devices (such as catheters, tubes, or lines) or non-elevated arms can introduce artifacts that reduce imaging quality.

Future research should focus on randomized controlled trials with larger cohorts to better define the risk-benefit profile of PCC. Additionally, exploring the role of viscoelastic testing (e.g., thromboelastography) in guiding PCC administration may further enhance its efficacy and safety.

CONCLUSION

In abdominal trauma, PCC effectively controls intra-peritoneal hematoma, stabilizes hemoglobin, reduces intra-abdominal pressure, restores tissue perfusion and coagulation, and improves ICU discharge rates. While our study supports its utility, careful patient selection and further research on individualized dosing and long-term outcomes are needed to optimize its use. Also, CT, X-ray, and FAST are essential, with contrast-enhanced CT being the most effective for classifying patients and guiding non-operative or surgical management. Early injury detection is crucial, particularly with the growing use of non-operative strategies, and CT also aids in follow-up and identifying initially missed complications.

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Author Contributions

Concept and design.
Acquisition, analysis, and interpretation of data.
Drafting of the manuscript, Critical review of the manuscript for important intellectual content,
Supervision, and approval of publication.

Conflicts of Interest

The authors declare that they have no conflicts of interest to disclose related to this work.

Confidentiality of Data

The authors affirm that all data collected were handled in accordance with confidentiality protocols approved by their institution. No identifying patient data has been published.

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