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Reduction of intra-abdominal pressure after percutaneous catheter drainage of pancreatic fluid collection predicts survival

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ABSTRACT

Objective: Intra-abdominal hypertension (IAH) can adversely affect the outcome in patients of acute pancreatitis (AP). Effect of percutaneous drainage (PCD) on IAH has not been studied. We studied the effect of PCD on IAH in patients with acute fluid collections.
Material and methods: Consecutive patients of AP undergoing PCD between Jan 2016 and May 2018 were evaluated for severity markers, clinical course, hospital and ICU stay, and mortality. Patients were divided into two groups: with IAH and with no IAH (NIAH). The two groups were compared for severity scores, organ failure, hospital and ICU stay, reduction in IAP and mortality.
Results: Of the 105 patients, IAH was present in 48 (45.7%) patients. Patients with IAH had more often severe disease, BISAP $\geq$2, higher APACHE II scores and computed tomography severity index (CTSI). IAH group had more often OF (87.5% vs. 70.2%, $p = 0.033$), prolonged ICU stay (12.5 vs. 6.75 days, $p = 0.007$) and higher mortality (52.1% vs. 15.8%, $p < 0.001$). After PCD, IAP decreased significantly more in the IAH group (21.85 $\pm$ 4.53 mmHg to 12.5 $\pm$ 4.42 mmHg) than in the NIAH group (12.68 $\pm$ 2.72 mmHg to 8.32 $\pm$ 3.18 mmHg), $p = <0.001$. Reduction of IAP in patients with IAH by >40% at 48 h after PCD was associated with better survival (63.3% vs. 36.7%, $p = 0.006$).
Conclusion: We observed that patients with IAH have poor outcome. PCD decreases IAP and a fall in IAP >40% of baseline value predicts a better outcome after PCD in patients with acute fluid collections.
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Introduction

Severe acute pancreatitis (AP) is one of the most catastrophic diseases in the critical care medicine. Mortality in patients with AP ranges from less than 1% in mild disease to 14–35% in severe disease [1]. Factors which predict poor outcome include clinical and radiological scores, serum markers, multiorgan failure, infected necrosis and intra-abdominal hypertension (IAH)/abdominal compartment syndrome (ACS) [2–9]. A number of these factors are inter-related and controlling one of them can influence the others.

Development of IAH/ACS is one of the most lethal complications of AP. First description of an elevated intra-abdominal pressure (IAP) was given by Marey and Burt, more than 135 years ago [10]. IAP is the steady-state pressure concealed within the abdominal cavity, the normal value described is 5–7 mmHg. IAH is defined by a sustained or repeated pathological elevation in IAP >12 mmHg. ACS is defined as a sustained IAP $\geq$20 mmHg (with or without an abdominal perfusion pressure (APP) < 60 mmHg) associated with new organ dysfunction/failure [11]. The incidence of IAH and ACS in SAP is around 60–80% and 13–27%, respectively and IAH is shown to be associated with multiple organ failure and increased mortality [12–15].

The current management of AP resolves around the “step up” approach [16], in which percutaneous or endoscopic drainage of necrotic/infected material forms the first step. Drainage of the necrotic/infected material is shown to be associated with a fall in inflammatory markers and cytokine levels [6]. However, there is limited data on the effect of drainage on IAH/ACS. The present study was therefore planned to evaluate the effect of percutaneous catheter drainage (PCD) of acute fluid collections in patients with AP on IAH. A secondary aim was to see if the fall in IAH could predict

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response to PCD.

Patients and methods

Patients

This study was a retrospective analysis of prospectively collected data on 105 consecutive patients of AP who were managed with PCD at a tertiary care centre in India between Jan 2016 and May 2018. The study was approved by Institute Ethics Committee. Exclusion criteria included patients with evidence of underlying chronic pancreatitis, prior PCD/radiological/surgical intervention, pregnant females, individuals with significant comorbidities like chronic kidney disease, cardiac disease and those on immunosuppression or with coagulation abnormality.

IAP measurement and monitoring protocol

IAP was measured by the U-tube technique [17], where a Foley's catheter was inserted into the bladder and was emptied. Following this 20–25 ml of sterile normal saline was instilled and pressure was measured taking midaxillary line as reference 0 level. World society of abdominal compartment syndrome definitions were used to define IAH as a sustained or repeated pathological elevation in IAP >12 mmHg and ACS as a sustained IAP ≥20 mmHg associated with new organ dysfunction/failure [11].

Baseline IAP was measured at admission after controlling severe pain using analgesics to minimize the possible confounding effect of pain on IAP. In patients undergoing any procedure which could cause pain, IAP measurement was delayed by at least 60 min. Subsequent IAP was measured prior to PCD insertion, andpost-PCD insertion at 6 h, 12 h, 24 h and 48 h. In patients who continued to have raised IAP after 48 h of PCD insertion, IAP was measured daily thereafter till normalization of the IAP value to below 10 mmHg for 48 h.

Treatment protocol

The diagnosis of AP was based on the revised Atlanta criteria [18]. OF was defined by modified Marshall score [4]. All the patients were managed according to standard recommendations including fluid resuscitation, organ system support, pain alleviation and nutritional support [19].

All the patients of AP underwent contrast enhanced computed tomography (CECT) abdomen on day 5–7 of pain onset or at admission [20]. Antibiotics were used for extrapancreatic infections and suspected or confirmed infected pancreatic necrosis which was suspected on clinical worsening, neutrophilia or elevation of procalcitonin. Confirmation of infected necrosis was based on culture positivity of the drain fluid or on presence of air foci within the collections [21].

'Step-up' approach was used for the management of peri/extrapancreatic fluid collections [22]. PCD was inserted by an interventional radiologist under image guidance (USG or CT). Choice of imaging guidance, size, site and route of PCD was decided by the radiologist. Indications of PCD included suspected or proven infection, persistent OF, pressure symptoms due to collections and failure to improve with conservative management [23,24]. Initial catheter size used was 12–14 Fr. To maintain the patency, PCD catheters were flushed using sterile normal saline every 8 hourly. PCDs were upgraded or additional PCDs were placed when there was worsening of or sepsis, or an inadequate drainage despite significant residual collection [1].

Complications of PCD noted include pain at insertion site, blockage, slippage or bleeding through the catheter and development of external pancreatic fistula (EPF). Definition of International Study Group of Post-operative Pancreatic Fistulae was used to define EPF i.e.clear pancreatic secretion of ≥100 ml per day persisted beyond 3 weeks of insertion of PCD [25]. Complications were managed as per the standard recommendation and indication.

Demographic data were collected for patients. Other data collected included body mass index (BMI), clinical and imaging severity scores (BISAP, APACHE II and CTSI), presence of organ failure, indications and duration of PCD, complications of PCD, duration of hospital stay, requirement of surgery and mortality.

Statistical analysis

All data were collected and entered in Microsoft excel 2010 and Statistical Product and Service Solutions (SPSS) software. The data was analysed using SPSS software {version 23.0 (Chicago IL), IBM}. Continuous variables were presented as mean ± standard deviation or median (interquartile range) and proportions were expressed as number (percentage). Independent sample *t*-test was applied to compare means of normally distributed variable between the two groups while Mann-Whitney *U* test was applied to compare the non-parametric distribution. Chi square test/Fisher's exact test was used categorical variables. Change in IAP between two groups was compared using mixed ANOVA, between the two groups at repeated time intervals, the difference was compared using univariate analysis. Among the groups, the change in intra-abdominal pressure was compared using repeated ANOVA. P value of less than 0.05 was taken as statistically significant.

Results

Baseline characteristics

A total of 105 patients underwent PCD and IAP monitoring during the study period. The mean age was 39.62 ± 12.28 years. Thirty five (33.3%) patients presented to our hospital within seven days of pain onset. A majority (n = 80, 76.1%) of patients were graded as severe AP as per the revised Atlanta classification [18].

Patients were classified into 'IAH group' and 'Non-IAH (NIAH) group', based on the presence or absence of IAH at the time of PCD, with 48 (45.7%) patients falling in the IAH group. Mean age, gender ratio, comorbidities and symptoms at presentation were not different between the two groups. Patients with IAH presented earlier to the institution compared to the patients in NIAH group (16.9 days vs. 31.7 days, respectively). Based on persistent OF criteria, IAH group had more severe disease compared to the NIAH group (87.5% vs. 64.9% respectively, p = 0.007) (Table 1).

Severity scores suggested more severe disease in the IAH group, with significantly higher APACHE II score (9.94 vs. 8.32, p = 0.038) and CTSI score (8.89 vs. 7.76, p = 0.003) in the IAH group (Table 1). Duration of ICU stay and mechanical ventilation was also higher in the IAH group (p value 0.007 and 0.021 respectively) (Table 2).

Organ failure characteristics

Out of 105 patients, 78.1% (82) patients had OF. A significantly higher number (87.5%) of patients in the IAH group had OF compared to the NIAH group (70.2%), p = 0.033. Presence of single OF was not different among the two groups but multi-organ failure was more common in the IAH group (47.9% vs. 28.1% respectively, p = 0.036). ALI was the most common OF in both the groups. Proportion of OFs resolved was not different among the two groups (Table 2).

PCD parameters

The mean number of PCDs placed was higher in the IAH group

Table 1
Baselines parameters of patients undergoing PCD in the two groups.

Parameter		IAH group	Non-IAH group	P value
Number of patients		48 (45.7%)	57 (54.3%)	
Age (mean ± SD) yrs		40.15 ± 13.39	39.18 ± 11.37	0.68
Gender	Male	36 (75%)	43 (75.4%)	0.95
Etiology of pancreatitis	Alcohol	26 (54.2%)	30 (52.6%)	
	Gallstone	15 (31.3%)	14 (24.6%)	
	Both alcohol and gallstone	2 (4.2%)	5 (8.8%)	
	Others	5 (10.4%)	8 (14%)	
Comorbidities		17 (35.4%)	18 (31.6%)	0.67
BMI (Kg/m^2)		23 ± 4.1	22.65 ± 3.51	0.65
Median time of presentation (range, days)		10 (1–83)	15 (1–180)	0.07
Severity of AP	Moderately severe	6 (12.5%)	20 (35.1%)	0.07*
	Severe	42 (87.5%)	37 (64.9%)	
SIRS		52 (91.2%)	45 (93.8%)	0.62
BISAP score	<2	5 (10.4%)	14 (24.6%)	0.06
	≥2	43 (89.6%)	43 (75.4%)	
APACHE II score		9.94 ± 3.97	8.32 ± 3.9	0.038*
CTSI score		8.98 ± 1.64	7.76 ± 2.3	0.003*
Infected pancreatic necrosis		12/35 (34.28%)	13/44 (29.54%)	0.72
Ascites		43 (89.6%)	45 (78.9%)	0.14
Organ failure	Overall	42 (87.5%)	40 (70.2%)	0.033*
	Single OF	19 (39.6%)	24 (42.1%)	0.79
	Multiple OF	23 (47.9%)	16 (28.1%)	0.036*
CRP before PCD (mg/dL)		613.7 ± 524	398.3 ± 503.88	0.038*

*: significant value, APACHE II: Acute physiology and chronic health evaluation, AP: Acute Pancreatitis, BISAP: Bedside index of severity in Acute Pancreatitis, BMI: Body mass index, CRP: C-reactive protein, CTSI: CT severity index, IAH: intra-abdominal hypertension, ICU: Intensive care unit, OF: organ failure, PCD: percutaneous drain, SIRS: Systemic inflammatory response syndrome.

Table 2
Comparison between patients in the IAH and NIAH groups.

Parameters		IAH group (48)	Non-IAH group (57)	P value
PCD parameters	Mean number of PCD	1.88 ± 0.93	1.47 ± 0.63	0.01*
	Single PCD	20 (41.7%)	34 (59.6%)	0.067
	≥2PCDs	28 (58.3%)	23 (40.4%)	
	Total duration of PCD (days)	37.98 ± 33.0	39.85 ± 31.45	0.77
Ascitic fluid drainage		13 (27%)	12 (21%)	0.47
OF resolution after PCD		24 (55.8%)	24 (64.9%)	0.41
Total duration of hospitalization (days)		33.94 ± 21.15	27.87 ± 16.4	0.1
Duration of ICU stay (days)		12.52 ± 11.61	6.75 ± 9.21	0.007*
Duration of mechanical ventilation (days)		5.44 ± 8.76	2.02 ± 5.14	0.021*
Surgery		6 (12.5%)	4 (7.1%)	0.35
Mortality		25 (52.1%)	9 (15.8%)	<0.001*
PCD related complications	Pain at PCD site	42 (87.5%)	46 (80.7%)	0.34
	PCD slippage	12 (25%)	9 (15.7%)	0.24
	Bleeding from PCD	2 (4.16%)	3 (5.2%)	0.79
	Cutaneous fistula	2 (4.16%)	5 (8.7%)	0.34

*: significant value, IAH: intra-abdominal hypertension, ICU: Intensive care unit, OF: organ failure, PCD: percutaneous drain.

(1.88 ± 0.93 vs. 1.47 ± 0.63 respectively, $p = 0.01$). However the requirement of single and multiple (≥2) PCDs was not different among the two groups ($p = 0.066$). The median interval between pain onset and PCD insertion (18 days versus 22 days in IAH and NIAH group, respectively) and the total duration of PCD were not statistically different among the two groups (Table 2). Catheter drainage of ascitic fluid was done in a total of 25 patients in the present study. Catheter drainage of ascites was done in patients who had high IAP with significant ascites along with large pancreatic/peripancreatic fluid collection(s) and both the drainages were done simultaneously. 13 (21%) patients in IAH group and 12 (27%) patients in NIAH group underwent ascitic fluid drainage and this proportion was statistically similar in both the groups ($p = 0.47$).

Change in intra-abdominal pressure

At presentation, 48 (45.7%) patients had IAH (including eight patients with ACS). Pre-PCD the mean IAP in the IAH and NIAH groups was 21.85 ± 4.53 mmHg and 12.68 ± 2.72 mmHg respectively, $p < 0.001$. After PCD, there was a fall in IAP in both the groups but the IAP remained significantly higher in the IAH group (12.5 ± 4.429 mmHg) than in the NIAH group (8.32 ± 3.18 mmHg) at 48 h (Fig. 1). At 48 h post-PCD, the mean reduction in IAP was significantly more (9.35 ± 5.32 mmHg vs. 4.36 ± 3.31 mmHg, $p < 0.001$) in the IAH group compared to the NIAH group. At subsequent time intervals, IAP decreased progressively in the IAH group and the reduction was statistically significant till 48 h (Supplementary figure 1). However in the NIAH group, the decrease in IAP was significant till 6 h post-PCD and further drop in IAP at 12 h, 24 h and 48 h was not statistically significant (Supplementary figure 1).

Mortality

The overall mortality was 31.4% in the present study and it was significantly higher in the IAH group (52.1% vs. 15.8%, $p < 0.001$) (Table 2). Subgroup analysis for IAH group showed that reduction of

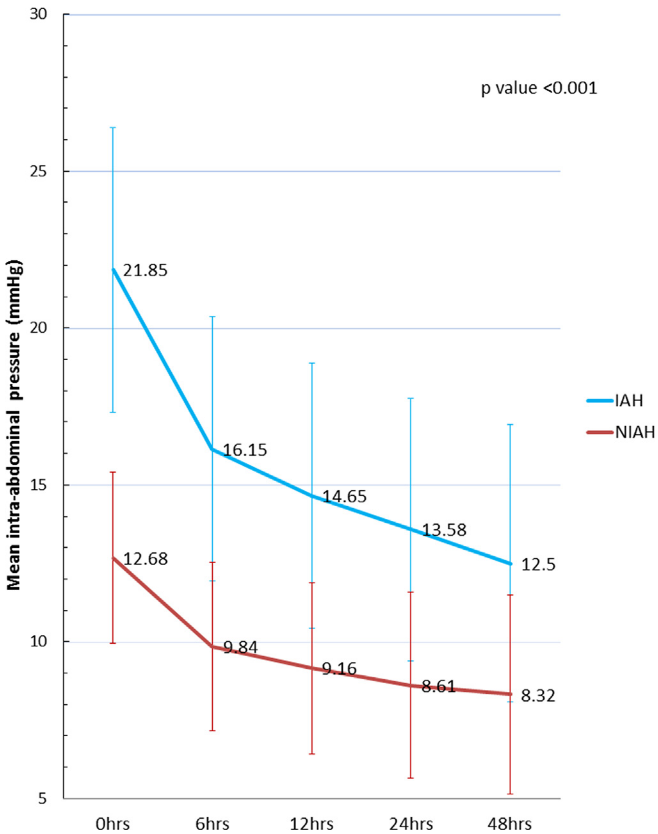

Fig. 1. Change in intra-abdominal pressure after percutaneous catheter drain placement among the two groups (IAH and NIAH groups).

IAP by >40% at 48 h after PCD was associated with better survival (63.3% vs. 36.7%, p = 0.006). In the present cohort, we had 8 patients of abdominal compartment syndrome which were managed with multiple PCD placements, and none underwent any surgical intervention. Out of these 8, 4(50%) patients survived and 4 expired.

On multivariate analysis, factors independently predicting mortality were presence of infected collection, multiple OF, presence of IAH (pre-drainage), fall in IAP <40% of the baseline and presence of IAH (pre-drainage) combined with IAP reduction <40% (post-drainage) (Table 3). Receiver operator curve (ROC) analysis showed area under curve (AUC) of 0.620, 0.726, 0.717, 0.603 and 0.828 for multiple OF, infected necrosis, presence of IAH (pre-drainage), IAP reduction <40% (post-drainage) and presence of IAH (pre-drainage) *with* IAP reduction <40% (post-drainage), respectively (Fig. 2). Presence of IAH (pre-drainage) *with* IAP reduction <40% (post-drainage) showed a sensitivity of 69.2% with highest specificity (96.3%) to predict mortality (Supplementary Table 1).

Discussion

We retrospectively evaluated the outcome of 105 patients of AP who had symptomatic fluid collections managed with PCD. Forty eight (45.7%) patients had IAH, while 57 (54.3%) did not have IAH. Following PCD, IAP decreased significantly in both the groups, with a persistent downward trend till 48 h in the IAH group while the decrease in the NIAH group was significant till 6 h post PCD. Also, a fall in IAP >40% following PCD was associated with better survival.

A variable proportion of patients with AP develop IAH. Elevation of IAP occurs within the first week of illness and is attributed to events initiated by pancreatic inflammation [13,15]. Pancreatic inflammation leads to pancreatic and visceral edema, peripancreatic fluid extravasation, capillary leak causing ascites, paralytic ileus and gastric dilatation [26–28]. Aggressive fluid resuscitation and large peripancreatic fluid collections can also contribute to IAH [29]. Maximum IAP has been shown to correlate with CTSI and other markers of severity including multiorgan failure [5,30–32], and understandably it correlates with mortality. We also found the patients with IAH to have greater severity of disease and higher mortality.

Management of patients with IAH/ACS involves medical measures like sedation, neuromuscular blockade, nasogastric decompression and correction of cumulative positive fluid balance [32]. IAH can be reduced by surgical means and image guided catheter drainage of abdominal or peripancreatic fluid collections. Surgically, a full thickness midline laparostomy or a subcutaneous linear alba fasciotomy are the most common procedures [32]. However surgical decompression has been reported to be associated with serious complications like pancreatic infection, septic shock and fistula formation [32].

The World Society of Abdominal Compartment Syndrome (WSACS) recommends PCD as the first step of intervention in such patients [11]. A few workers have carried out drainage of abdominal fluid or ascites [33–35]. Sun et al. described a decrease in IAP from 29 to 14 mmHg after draining ascites in 45 patients [36]. Wang et al. showed that a fall in IAP >6.5 mmHg after abdominal catheter drainage correlated with better outcome [35]. Our study is based only on patients with acute fluid collections who underwent PCD. We noted that PCD resulted in a significant fall in IAP in patients with both IAH and without IAH, although a greater fall was noted in the IAH group. The mean fall in IAP was 9.35 ± 5.32 mmHg in the IAH group and 4.36 ± 3.31 in the NIAH group at 48 h post-PCD.

There is a limited data on the effect of PCD (of peripancreatic fluid collections) on IAH. Papavramidis et al. showed a steady decline in IAP after PCD in patients with large pseudocyst [37]. The fall in IAH was most dramatic on the first day, and it gradually plateaued by fifth day. In a control group of 18 patients, who did not undergo PCD, the IAP remained almost static. Our study also showed maximum fall in IAH in the first 6 h. Patients with IAH continued to have significant fall till the study endpoint of 48 h while those in the NIAH group had smaller fall in IAP beyond 6 h.

In our study, patients with >40% fall in the IAP after PCD had

Table 3
Multivariate analysis for mortality.

Variables	Beta co-efficient	p value	Adjusted OR	95% CI of adjusted OR
Age	−0.001	0.983	0.999	0.952–1.049
Comorbidities	−0.689	0.332	0.502	0.125–2.018
Severe disease (revised Atlanta)	1.369	0.235	3.931	0.410–37.688
Infected pancreatic necrosis	1.542	0.027*	4.673	1.14–18.284
Multiple OF	1.350	0.039*	3.858	1.073–13.864
Presence of IAH	2.120	0.004*	8.330	1.961–35.390
IAP reduction <40% at 48 h	1.563	0.028*	4.774	1.182–19.282

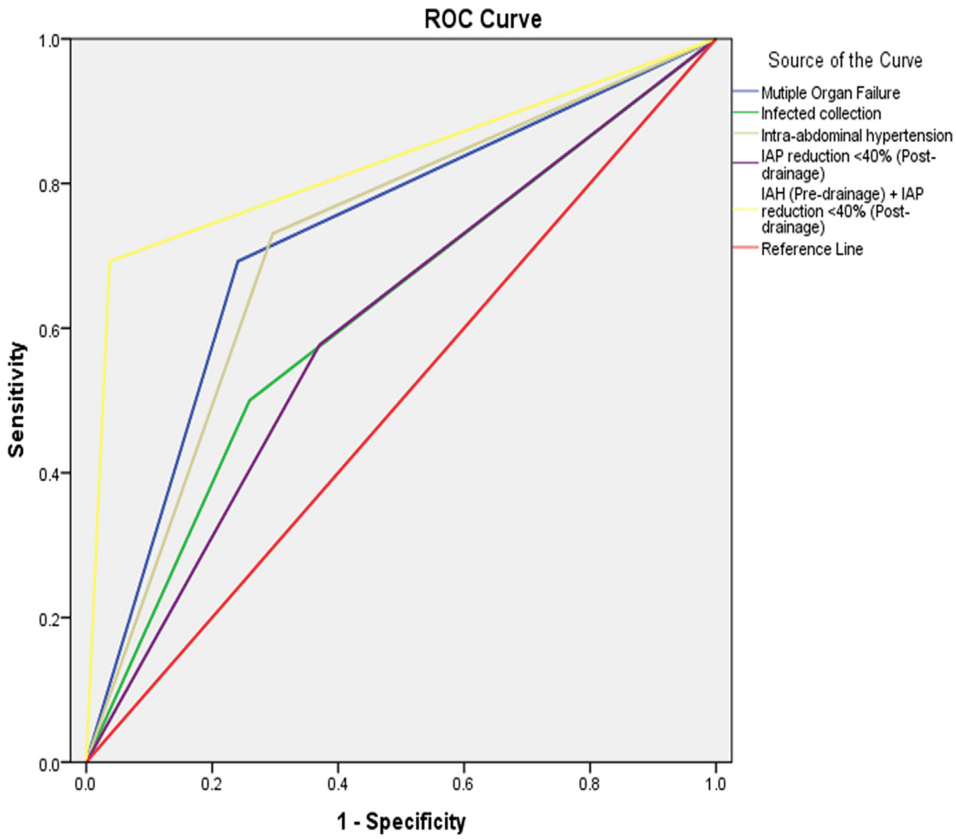

Fig. 2. ROC curve for predicting mortality.

better survival. A significant fall in IAP after PCD may explain how PCD accrues benefit to patients with IAH. A fall in IAH is likely to reverse the pathophysiology set into motion by elevated IAH, namely cytokine release, poor abdominal perfusion, organ failure and secondary infection. We have earlier shown that a fall in the levels of inflammatory cytokines occurs after PCD and correlates with outcome of patients with acute fluid collections [6]. In another study we showed that more than 50% reduction in the size of fluid collection after PCD predicts better outcome [38]. The results of the present study provide another explanation of how drainage of acute fluid collections helps.

There were no major complications of PCD in our study. Up to 83.9% patients had mild pain at the PCD site, PCD slipped in 20% patients requiring reinsertion, bleeding and fistulae formation were reported in 4.7% and 6.7% respectively. The PCD complications in the current study were acceptable as in other studies [38].

Our study is not only the first one to document the effect of PCD on IAP in patients with IAH, but also shows that a >40% fall in IAP at 48 h post-PCD correlates with better survival in such patients. There are a few limitations, though. Firstly, the retrospective design was an important limitation although we had recorded the data prospectively with IAP monitoring being routinely done in our department. Secondly, being a retrospective study, we could not get the CT scan images to measure the size of fluid collections and possible correlation of collection size on IAP and the effect of PCD on the size of collection. Thirdly, in a group of patients, ascitic fluid drainage was done simultaneously along with that of fluid collections and hence the effect of ascitic fluid drainage could not be evaluated separately. Fourthly, our study population was a highly selected group of patients, those who were candidates for PCD and in whom it was technically feasible.

In the present study, the median interval between onset of pain and PCD was 20 days (mean 31.79 ± 30.7 days). Most of the studies on IAH have studied its impact during the first few days of onset of AP. Moreover, it has been shown that IAH sets in within the first few days of onset of AP and plateaus after 5 days [37]. It has been suggested that in the course of AP, a number of factors affect the dynamics of IAH beyond the first week. These include compliance of the abdominal wall, properties of the diaphragm and muscle contraction [37]. Presence of fluid collection and ascites also contribute to IAH. Ascites was present equally in patients with and without IAH and was mild to moderate in all. In both the groups, ascites was drained in a limited number of patients and its prevalence was not different among the two groups Others have reported that ascitic fluid drainage can decrease IAH [33–35].

No studies are available on the clinical relevance of IAH in the later stage of the disease. Our study suggests that IAH may be of concern even in the later course of the disease. Therefore monitoring of IAH may make a clinical difference even in late AP, especially in patients undergoing a drainage procedure. Serial measurement of inflammatory cytokine levels along with the fall in IAP would further give an insight into the beneficial pathophysiological changes following PCD and needs to be studied. To conclude, our study has shown that >40% reduction in IAP after PCD predicts survival and more importantly in patients with pre-drainage IAH.

Guarantor of the article

Rakesh Kochhar.

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Declaration of competing interest

The authors declare that they have no conflict of interest.

Abbreviations

ACS	Abdominal compartment syndrome
AP	Acute pancreatitis
APACHE	Acute Physiology, Age, Chronic Health Evaluation II
CRP	C-reactive protein
CTSI	Computed Tomography Severity Score
IAH	Intra-abdominal hypertension
SIRS	Systemic inflammatory response syndrome

Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.pan.2020.04.012.

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