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GASTRIC VENOUS CONGESTION AFTER TOTAL PANCREATECTOMY: HOW SERIOUS IS THE PROBLEM?

D.A. Chichevatov[1], V.V. Kalentjev[2], A.E. Glukhov[1]

[1]Penza State University
40, Krasnaya St., Penza, 440026, Russia
[2]Penza Regional Oncology Hospital
37a, Prospect Stroiteley, Penza, 440066, Russia

Abstract

Introduction. Gastric venous congestion (GVC) after total pancreatectomy (TP) remains a challenging condition which may result in stomach necrosis or bleeding. Here, we present a short series of TPs with two cases of GVC successfully managed by restoring the coronary vein outflow. **Material and Methods.** A total of 11 patients were eligible for our study due to stomach-preserving TP. The incidence of GVC and risk factors were estimated. **Results.** GVC was observed in 2 of 11 patients (18.2 %). The complication was successfully managed by the reconstruction of the gastric coronary vein. The regression model revealed that coronary vein ligation was the only significant predictor of GVC (OR=10.38 [3.97–27.94]). The risk of GVC with the preserved coronary vein was low (OR=0.12 [0.02–0.55]). No gastrectomy was required in both cases. **Conclusion.** GVC is a frequent complication of total pancreatectomies which may result in life-threatening conditions, such as stomach necrosis or bleeding. Gastric coronary vein reconstruction is a safe procedure which allows the surgeon to escape unnecessary gastrectomies.

Key words: total pancreatectomy, pancreatoduodenectomy, gastric venous congestion, gastric venous reconstruction.

ЖЕЛУДОЧНАЯ ВЕНОЗНАЯ ГИПЕРТЕНЗИЯ ПОСЛЕ ПАНКРЕАТОДУОДЕНЭКТОМИИ: НАСКОЛЬКО ВАЖНА ЭТА ПРОБЛЕМА?

Д.А. Чичеватов[1], В.В. Калентьев[2], А.Е. Глухов[1]

[1]ФГБОУ ВО «Пензенский государственный университет»
Россия, 440026, г. Пенза, Красная, 40
[2]Пензенский областной онкологический клинический диспансер
Россия, 440066, г. Пенза, пр-т Строителей, 37а

Аннотация

Введение. Желудочная венозная гипертензия (ЖВГ) после тотальной панкреатодуоденэктомии (ТП) остается серьезным осложнением, которое может привести к некрозу желудка или желудочному кровотечению. В настоящем исследовании мы приводим короткую серию ТП с двумя случаями ЖВГ, которая была успешно ликвидирована путем реконструкции левой желудочной (коронарной) вены. **Материал и методы.** В исследование включены 11 пациентов, перенесших ТП. Были проанализированы частота ЖВГ и факторы риска ее развития. **Результаты.** Желудочная венозная гипертензия возникла у 2 (18,2 %) из 11 пациентов. Осложнение было успешно ликвидировано путем редренирования левой желудочной вены. Регрессионный анализ показал, что только перевязка левой желудочной вены была значимым предиктором развития ЖВГ (ОШ=10,38 [3,97–27,94]). Риск ЖВГ при сохраненной левой желудочной вене был низким (ОШ=0,12 [0,02–0,55]). Ни в одном случае не потребовалась гастрэктомия или резекция желудка для ликвидации осложнения. **Заключение.** ЖВГ является частым следствием панкреатодуо-

Чичеватов Дмитрий Андреевич, chichevatov69@mail.ru

денэктомии, которое может закончиться развитием жизнеугрожающих осложнений в виде желудочного кровотечения или некроза желудка. Реконструкция левой желудочной вены – безопасная процедура, позволяющая восстановить венозный кровоток в желудке и избежать вынужденных гастрэктомий.

Ключевые слова: панкреатэктомия, панкреатодуоденэктомия, желудочная венозная гипертензия, реконструкция вен желудка.

Introduction

Gastric venous congestion (GVC) after total pancreatectomy (TP) remains a challenging condition. Recently, Loos et al. [1] have reported a high rate (27.9 %) of this complication, which required total or partial gastrectomy. Since TP results in the utmost gastric venous deprivation, the subsequent stomach necrosis may be an expected dramatic event. Nevertheless, studies dedicated to GVC after TP are scarce. As noted in those studies, splenectomy (odds ratio of 2.14) and coronary vein resection (odds ratio of 5.49) were independent risk factors of GVC [1]. Whilst splenectomy is most often a default part of TP, the coronary vein transection should be avoided, given the high risk of GVC [1]. Unfortunately, the vein-sparing surgery is not possible every time, especially in the case of a pancreatic carcinoma with true invasion into the distal part of the portal vein and its tributaries. Here, we present a short series of TPs with two cases of GVC successfully managed by restoring the coronary vein outflow.

Material and Methods

Penza informational and analytical medical system identified 13 patients who underwent TP from 2015 to 2025. Of the 13 patients, 11 were eligible for our study because they had stomach-preserving TP, while 2 patients were excluded because they had undergone total and subtotal gastrectomy for cancer. The patients' characteristics, surgery details and perioperative complications are presented in Table 1. The morbidity and mortality were assessed during the hospitalization and 30 days after.

All TP procedures were performed in a subtotal stomach-preserving manner with the resection of ½ of the antral part of the stomach. Given the splenic vein cut in all the cases, we sought to preserve at least one gastric vein: the coronary or the right gastroepiploic ones.

If required, arterial and venous vascular resections and reconstructions were implemented. All these techniques were performed under the optical magnification of 4 x, using microsurgical instruments and non-absorbable surgical sutures size 7-0 or 6-0.

The diagnosis of GVC was established intraoperatively on the basis of the following signs: (1) the stomach serosa's cyanic color, (2) dilation of lesser (greater) gastric curvature veins, (3) edema of the stomach wall, (4) petechiae of the gastric serosa. No extra diagnostics were applied.

We used only a regression model to estimate the predictors' impact and the grade of the GVC risk. The patients' characteristics and surgery details played a role of potential predictors whereas the binary variable

Table 1/Таблица 1

The patients' characteristics, surgery details, and perioperative complications

Характеристики пациентов, особенности операции и послеоперационные осложнения

Characteristic/Характеристика	Value/Значение
Sex (male/female)/Пол (мужской/женский)	6/5
Age/Возраст (q1-med-q3)	55.0 – 61.0 – 70.0
TNM: T3 – T4	9 – 2
TNM: N0 – N1 – N2	6 – 4 – 1
Pancreatic carcinoma/Протоковая аденокарцинома: G1 – G2 – G3	1 – 1 – 9
Neuroendocrine tumor/Нейроэндокринный рак: G1 – G2	1 – 1
Neoadjuvant chemotherapy/Неоадъювантная химиотерапия	2
Surgery details/Особенности операции	
PVR/ПВР:	8
- with direct anastomosis/с прямым анастомозом	5
- with prosthetic replacement/с протезированием	3
Arterial resection/Артериальные резекции: SMA – HA	2 – 1
Coronary vein preservation/Сохранение коронарной вены	9
Contemporary colon resection/Резекция ободочной кишки	3
Intraoperative GVC/Интраоперационная ЖВГ	2
Postsurgical complications/Послеоперационные осложнения	
Clavien–Dindo: Grade II – IIIb – V	1 – 1 – 3

Notes: PVR – portomesenteric venous resection; SMA – superior mesenteric artery; HP – hepatic artery; created by the authors.

Примечания: ПВР – портомезентериальная венозная резекция; SMA – superior mesenteric artery/верхняя брыжеечная артерия; HP – hepatic artery/печеночная артерия; таблица составлена авторами.

"GVC" (yes, no) was an outcome. Therefore, a logistic regression was chosen.

All the statistical calculations were implemented using the freely available R programming language (v. 4.4.1) and the integrated developer environment RStudio 2024.09.1 Build 394 © 2009–2024 Posit Software, PBC. The descriptive statistics was estimated applying the basic built-in libraries of the RSudio. The values of $p<0.05$ were considered significant when testing the hypotheses. The main outcome (GVC) was modeled by the Generalized Linear Regression Models. We applied the Bayesian math on the basis of the brms software library (Bayesian Regression Models using "Stan", v. 2.21.0, https://github.com/paul-buerkner/brms).

Since the "GVC" might take only two qualitative values (levels), the Bernoulli probability density function with the logarithmic link-function were chosen for modeling the distribution of the dependent variable (logistic regression). While the regression model assumed individual variability (random-effects models), it could be multilevel with an individual intercept.

As we dealt with the study group of a small size (n=11), the Bayesian regression was considered preferable, since the Bayesian mathematical approach is more resistant to the phenomenon of small samples. Given the published information about odds ratios for coronary vein ligation considered a predictor, we used informative priors for this regression coefficient in our own model. The Bayesian framework implied interval assessment of variance.

Results

Five postsurgical complications were observed in the operated patients: one colonic anastomosis leakage resulted in the peritoneal sepsis, one case of the left hepatic lobe necrosis followed by liver failure, one eventration, one delayed gastric emptying, and one severe pneumonia accompanied by respiratory failure. Only 8 of 11 patients were successfully discharged.

Gastric venous congestion was observed in 2 (18.2 %) of 11 patients. The baseline averaged risk of GVC (intercept only regression model) was as low as OR=0.22 [0.04–0.86] with a wide high-density interval (HDI). Neither of the univariate regression models revealed association between GVC and the sex, age, T, N, portomesenteric venous resection, and arterial resection. Only ligation (preservation) of the coronary vein significantly affected the GVC's likelihood. According to leave-one-out (LOO) cross-validation, multilevel models with individual intercept were inferior to fixed effect only models (LOO-comparison: elpd_diff=0.0 *vs* elpd_diff=-0.8). Finally, two logistic regression models where "GVC" was considered the response variable, while the coronary vein ligation (the "CVL" variable) was the single predictor were fitted (Table 2).

In the model with weakly-informative priors the odds ratio for CVL was 23.33 [1.49–424.11]. The model with the informative prior which was calculated on the basis of two publications [1, 2], narrowed this considerable uncertainty significantly, with the GVC OR=10.38 [3.97–27.94]. The Bayesian R^2 for this model was 0.36 [0.02–0.76]. The risk of GVC, when the coronary vein was preserved, was low (OR=0.12 [0.02–0.55]). Posterior predictive check (Fig. 1) exhibits the limited prognostic ability of the model.

Whereas the two GVCs we observed developed during the surgical procedure, they were attended immediately. In both cases, the patients underwent portomesenteric resection with CVL. Gastrectomy for GVC was rejected in favor of stomach-preserving surgery, and venous reconstruction was performed. In the first case, the coronary vein stump was anastomosed to the left renal vein end-to-side (Fig. 2A). Figure 2B represents the enhanced CT image of this patient at postoperative

Table 2/Таблица 2

Regression models

Регрессионные модели

Family: Bernoulli; Links: mu=logit; Formula: GVC ~ 1 + CVL; Data: df (Number of observations: 11)/Распределение Бернулли; Функция связи: логит-преобразование; Модель: GVC ~ 1 + CVL; Количество наблюдений: 11

Draws: 4 chains, each of iter=4 000; warmup=2 000; thin=1; total post-warmup draws=8 000/Аргументы функции моделирования brm пакета brms: количество цепей=4; количество итераций в цепи=4000; период прогрева=2000 итераций; толщина цепи=1; выбрано после прогрева=8 000 итераций

Regression coefficients/Коэффициенты регрессии:

	Estimate/ Оценка параметра	SE	l-95 %	u-95 %	$\hat{R}$	Bulk_ESS	Tail_ESS
Intercept[a]/Константа	–2.37	1.04	–4.67	–0.62	1.00	3500	3074
β_CVL[a]/β _CVL	3.15	1.46	0.40	6.05	1.00	3994	3578
Intercept[b]/Константа	–2.12	0.84	–3.91	–0.60	1.00	4886	4283
β _CVL[b]/β _CVL	2.34	0.50	1.38	3.33	1.00	4530	4551

Notes: a-weakly informative prior (beta ~ normal (0.2)); b-informative prior (beta ~ normal (2.09, 0.51)); created by the authors.

Примечания: SE – стандартная ошибка оценки; l–95 % – нижняя граница 95 % доверительного интервала; u-95 % – верхняя граница 95 % доверительного интервала; $\hat{R}$ – потенциальный коэффициент уменьшения масштаба; Bulk_ESS – эффективное количество выбранных значений для центральной части апостериорного распределения; Tail_ESS – эффективное количество выбранных значений для «хвостов» апостериорного распределения; a-weakly informative prior (beta ~ normal (0, 2))/слабоинформативное априорное распределение; b-informative prior (beta ~ normal (2.09, 0.51))/информативное априорное распределение; таблица составлена авторами.

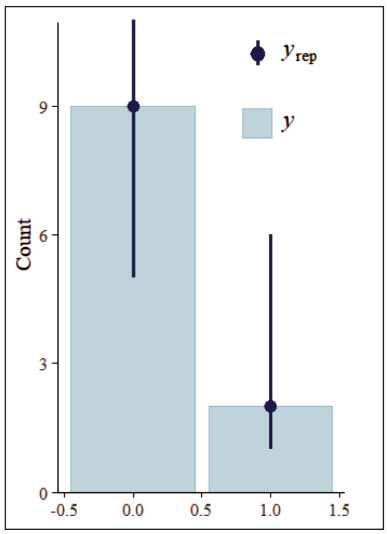

Fig. 1. Posterior predictive check: y – row values; y_{rep} – predicted values. Note: created by the authors
Рис. 1. Апостериорная проверка предиктивности модели: y – исходные данные; y_{rep} – прогнозируемые значения. Примечание: рисунок выполнен авторами

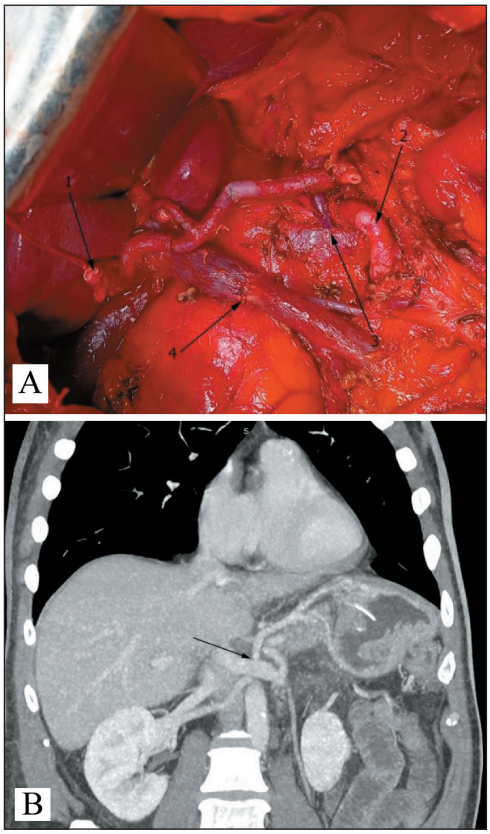

Fig. 2. A. TP with PMR: 1 – the stump of the common bile duct; 2 – SMA; 3 – the anastomosis of the gastric coronary vein to the left renal vein; 4 – the portomesenteric anastomosis. B. The CT scan of the same patient at postoperative day 7. The arrow points to the well-functioning venous anastomosis. Note: created by the authors
Рис. 2. А. ТП с ПВР: 1 – культя общего желчного протока; 2 – верхняя брыжеечная артерия; 3 – анастомоз левой желудочной и левой почечной вен; 4 – портомезентериальный анастомоз. Б. КТ скан того же пациента на 7-е сут после операции. Стрелка указывает на хорошо функционирующий венозный анастомоз.
Примечание: рисунок выполнен авторами

day 7. In the second case, the anatomic features did not allow us to form a direct porto-caval anastomosis. The coronary vein re-draining was achieved by end-to-end anastomosis to the inverted right ovarian vein (Fig. 3). Both procedures were successful.

Discussion

Currently, GVC after TP is either a well-known or underestimated complication. It is expected to result in gastric venous infarction succeeded by the perforation and major peritoneal complications. Despite the ever-increasing rate of extended TPs, the relevance of GVC remains unclear. This ambiguity may be caused by only sparse publications that does not allow the preparation of a systematic review. As mentioned by Stoop et al. [2], their study "that investigated potential risk factors, outcome, and management of GVC among consecutive patients who underwent TP" was only the second one published.

The genuine rate of GVC still stays unknown. Referencing to other authors, Yamanaka et al. ranged the GVC incidence from 5.3 % to 27.9 % [3]. Stoop et al. [2] demonstrated the GVC incidence as high as 21 % among 268 consecutive patients. Since the latter was a large study, one may consider its results as sufficiently averaged and justified. What is more substantial, GVC has serious implications such as inevitable gastrectomies, increased morbidity and mortality rate [1, 2]. Stoop et al. [2] performed 29 subtotal or total gastrectomies in 57 patients to manage GVC. The authors declared 43.9 % of the major postoperative morbidity in this group, as well, that is almost twice as high as that in patients without GVC. Loos et al. [1] noted that 12 of 24 patients (50.0 %) who died after TP, had GVC.

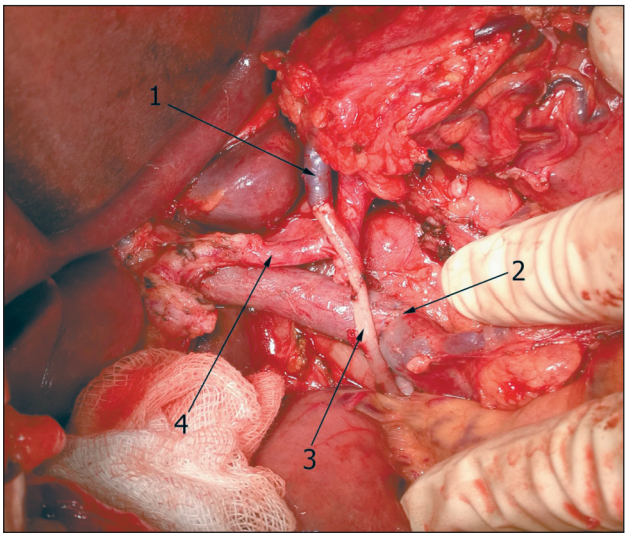

Fig. 3. TP with PMR: 1 – the gastric coronary vein; 2 – the portomesenteric anastomosis; 3 – the right gonadal vein; 4 – HA. Note: created by the authors
Рис. 3. ТП с ПВР: 1 – левая желудочная вена; 2 – портомезентериальный анастомоз; 3 – правая гонадная вена; 4 – печеночная артерия.
Примечание: рисунок выполнен авторами

Along with gastric venous infarction, bleeding may be another life-threatening side effect of GVC [3, 4]. Such hemorrhages may be massive and uncontrolled, requiring a total gastrectomy [3]. In the series of TPs performed by Nakao et al. [4], gastric bleeding developed in 5.3 % (2 of 38 patients). These were patients with no preservation of the stomach vein drainage. In one case, the hemostasis was achieved by re-draining the right gastroepiploic vein into the left ovarian one.

Undoubtedly, the risk factors of GVC are the point of a great surgical interest. As mentioned above, only several publications are available on this problem. Despite the evidence of the gastric veins deprivation playing a key role, this aspect requires a more detailed assessment. Some authors revealed splenectomy (odds ratio of 2.14) and coronary vein resection (odds ratio of 5.49) as independent risk factors [1]. Stoop et al. [2] identified an even higher risk (odds ratio of 11.9) of GVC considering the left gastric vein ligation as a predictor. The authors did not separate splenic and left gastric veins ligation as independent risk factors, since they were contemporary in their series. Apart from veins deprivation, the authors revealed some additional risk factors of GVC, such as portomesenteric venous resection (PVR). Several other factors like malignancy or perioperative chemo(radio)therapy were associated with GVC [2].

Hence, the careful handling and preservation of gastric veins becomes a crucial condition for the GVC prevention. Some authors even classified the TP procedures based on which venous basin was preserved [4]. They concluded that any functioning left or right gastric venous basin could prevent GVC. Other authors made the same inference, as well [5]. Recently, H. Lee and J. Lee have published their own classification of anatomic variants of the left gastric vein [6]. Knowing it makes preparation of the coronary vein more precise and careful. V. Bedin et al. [7] did appreciate this classification and interpreted preoperative 3D CT images according to it.

Unfortunately, vein-sparing surgery may not be technically possible due to the tumor volume. For example, in the series of TPs by Nakao et al. [4], the authors failed to save at least one venous basin in 18 of 38 patients. In such a case, only the venous drainage restoration appears the technique of choice, which has already been applied [4, 8]. Such an approach is not a conventional one, therefore, the corresponding publications are mostly case reports [5, 8]. Mehrabi et al. initiated an original study to evaluate the efficiency and safety of the venous reconstruction [9].

In our own series of TPs, the rate of GVC (18.2 %) was comparable to that reported previously [1–3]. No other variable, except the CVL, was revealed as a significant predictor of GVC. Such an inference coincides with that reported by other authors, hence, this complication is expected to show high incidence.

We believe that the importance of sparing the gastric veins is evident. Unfortunately, the studies, where the authors estimate the risk of GVC after the ligation of gastric veins are not numerous. Technically, the coronary vein is thought to be the first if not a single candidate for sparing. For example, in the study by Nakao et al. [4] it is involved in the majority of cases. It is CVL that other authors estimated as a substantial predictor of GVC [1, 2]. What is a true risk of GVC after CVL? So far, we have encountered only two values mentioned in the literature: 5.5 times higher [1] and 12.0 times higher [2]. Our own assessment is close to that reported by Stoop et al. [2]. It matches the intuitive expectations based on the fact of the utmost venous outflow reduction.

Although stomach veins preservation has been proved to be important, it becomes a less realistic procedure as the rate of PVR increases (72.7 % in our short series). Not every time, but rather frequently a surgeon has to excise the exact portomesenteric segment, where the tributaries confluence. Under such circumstances, either gastrectomy or gastric veins restoration emerge as two alternatives which may help to prevent the life-threatening complications. We believe the latter is preferable, although seems more complex. The ligated and dilated coronary vein is usually a well-identified vessel which has a proper diameter. Even if there are local anatomical difficulties in the veins' connection, the gonadal vein may be used as a helpful surgical trick. This parietal vessel has a thick wall, an appropriate diameter, and it is invariable in the anatomical sense. It may be inverted and, being long enough, may reach the area of the surgical interest. Such a technique was described by Nakao et al. [4]. Thus, the current TPs are more aggressive and complex procedures, and GVC is respectively a more frequent important problem than it would have been expected.

Limitations

The low number of observations (n=11) caused the high variance and uncertainty of estimates. Nevertheless, application of the Bayesian mathematical approach, more resistant to the phenomenon of small samples, and usage of the informative prior allowed us to make a more precise inference.

Conclusion

GVC is a common complication of total pancreatectomies which may result in life-threatening conditions such as stomach necrosis or bleeding. Gastric coronary vein reconstruction is a safe procedure which allows escaping unwanted gastrectomies.

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ABOUT THE AUTHORS

Dmitry A. Chichevatov, MD, DSc, Professor, Department of Surgery, Penza State University (Penza, Russia). Researcher ID (WOS): Q-3647-2017. ORCID: 0000-0001-6436-3386.
Vyacheslav V. Kalentjev, MD, MSc, Surgeon, Department of Surgery, Penza Regional Oncology Hospital (Penza, Russia).
Artem E. Glukhov, MD, MSc, Assistant, Department of Surgery, Penza State University (Penza, Russia).

AUTHOR CONTRIBUTIONS

Dmitry A. Chichevatov: the conception and design of the study, acquisition of data, analysis and interpretation of data.
Vyacheslav V. Kalentjev: drafting the article and revising it critically for important intellectual content.
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The authors declare that they have no conflict of interest.

СВЕДЕНИЯ ОБ АВТОРАХ

Чичеватов Дмитрий Андреевич, доктор медицинских наук, профессор кафедры хирургии, ФГБОУ ВО «Пензенский государственный университет» (г. Пенза, Россия). Researcher ID (WOS): Q-3647-2017. ORCID: 0000-0001-6436-3386.
Калентьев Вячеслав Викторович, абдоминальный хирург, Пензенский областной онкологический клинический диспансер (г. Пенза, Россия). SPIN-код: 3235-6383.
Глухов Артем Евгеньевич, ассистент кафедры хирургии, ФГБОУ ВО «Пензенский государственный университет» (г. Пенза, Россия). SPIN-код: 9136-7827.

ВКЛАД АВТОРОВ

Чичеватов Дмитрий Андреевич: концепция и дизайн исследования, сбор данных, анализ и интерпретация данных.
Калентьев Вячеслав Викторович: написание статьи и ее критический пересмотр на предмет важного интеллектуального содержания.
Глухов Артем Евгеньевич: написание статьи и ее критический пересмотр на предмет важного интеллектуального содержания.
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