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Supplementary Material

Which Suture to Choose in Hepato-Pancreatic-Biliary Surgery? Assessment of the Influence of Pancreatic Juice and Bile on the Resistance of Suturing Materials—In Vitro Research

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1. BASE STATE ASSESSMENT (BRAND NEW SURGICAL SUTURES)

Table S1. Amylase and lipase levels in pancreatic juice before freezing and after thawing along with pH measurements of pancreatic juice and bile.

Nr	Amylase (before freezing) U/l	Amylase (after thawing) U/l	Lipase (before freezing) U/l	Lipase (after thawing) U/l	pH pancreatic juice	pH bile
1	157 400	138 920 / 122 700	789 200	722 050 / 693 050	+/- 7,7	+/- 6,8
2	66 440	40 900	392 400	196 200		
3	84 100	78 560	702 600	577 000		
4	21 260	20 260	84 590	84 060		

There was a slight decrease in amylase and lipase levels after thawing (mean decrease for amylase = 16.48% and for lipase = 17.64%).

Table S2. Assessment of the tensile strength of the reference surgical sutures used in the test (brand new threads).

REFERENCE STATE											
Tensile Srength R_m (MPa)	arithmetic average	Median	Min.	Max.	Lower Quartile	Upper Quartile	Standard deviation	Standard Error	Skewness	Kurtosis	Test Shapiro-Wilka
MONOCRYL	236.5	238.1	211.6	273.9	217.4	239.8	21.92	8.95	0.8556	1.2525	p = 0,3933
MONOCRYL Plus	268.7	268.9	222.3	305.0	251.0	296.0	31.14	12.71	-0.3661	-0.9902	p = 0,7751
PDS	117.2	112.7	109.6	132.5	110.5	125.0	9.38	3.83	1.1627	-0.3114	p = 0,0727
PDS Plus	127.8	127.4	116.4	138.7	122.6	134.4	8.26	3.37	-0.0489	-1.0993	p = 0,9342
VICRYL	293.0	305.8	238.9	320.2	281.0	306.3	29.37	11.99	-1.5789	2.4181	p = 0,0864
VICRYL Plus	282.8	278.1	262.6	315.0	263.8	299.3	22.11	9.03	0.4988	-1.7340	p = 0,1953

- Levene's test showed homogeneity of variance: p = 0.0511
- ANOVA test showed a statistically significant difference in the Rm level between the study groups (p <0.0001)

Table S3. ANOVA statistical test results for the reference tensile strength (brand new threads): SS - sum of squares, MS - sum of mean squares, F - F index (F distribution)

ANOVA TEST	SS	Degrees of freedom	MS	F	p
Intercept	1758079	1	1758079	3565.931	< 0.0001
Material	185850	5	37170	75.392	**< 0.0001**
Error	14791	30	493		

Table S4. Results of Tukey's post-hoc tensile strength test for reference suture state.

Material	MONOCRYL	MONOCRYL Plus	PDS	PDS Plus	VICRYL	VICRYL Plus
MONOCRYL	p =	0.1523	**0.0001**	**0.0001**	**0.0017**	**0.0127**
MONOCRYL Plus	0.1523	p =	**0.0001**	**0.0001**	0.4248	0.8768
PDS	**0.0001**	**0.0001**	p =	0.9590	**0.0001**	**0.0001**
PDS Plus	**0.0001**	**0.0001**	0.9590	p =	**0.0001**	**0.0001**
VICRYL	**0.0017**	0.4248	**0.0001**	**0.0001**	p =	0.9666
VICRYL Plus	**0.0127**	0.8768	**0.0001**	**0.0001**	0.9666	p =

- Tukey's post-hoc test showed a statistically significant difference in the Rm level between:
MONOCRYL vs. PDS;
MONOCRYL vs. PDS Plus;
MONOCRYL vs. VICRYL;
MONOCRYL vs. VICRYL Plus;
MONOCRYL Plus vs. PDS;
MONOCRYL Plus vs. PDS Plus;
PDS vs. VICRYL;
PDS vs. VICRYL Plus;
PDS Plus vs. VICRYL;
PDS Plus vs. VICRYL Plus.

2. **EVALUATION OF THE INFLUENCE OF THE EXPOSURE TIME ON THE TENSILE STRENGTH (Rm) - STERILE ENVIRONMENT**

Table S5. Results of tensile strength tests of Monocryl sutures in saline (sterile environment).

MONOCRYL											SALINE - STERILE ENVIRONMENT
Tensile Srength R_m (MPa)	arithmetic average	Median	Min.	Max.	Lower Quartile	Upper Quartile	Standard deviation	Standard Error	Skewness	Kurtosis	Test Shapiro-Wilka
Reference	236.5	238.1	211.6	273.9	217.4	239.8	21.92	8.95	0.8556	1.2525	p = 0,3933
7 days	132.7	136.2	113.5	149.4	116.8	143.9	14.58	5.95	-0.4545	-1.6955	p = 0,4524
14 days	93.0	94.0	78.0	112.5	81.3	98.1	12.59	5.14	0.4015	-0.1993	p = 0,7746
21 days	35.3	35.7	30.4	41.2	32.0	36.6	3.79	1.55	0.3312	0.1625	p = 0,8155
28 days	6.9	7.1	5.7	7.7	6.5	7.4	0.69	0.28	-0.9257	0.5636	p = 0,6697

- The ANOVA test showed a statistically significant difference in the Rm level between all exposure times (**p <0.0001**) (i.e. statistically significant dynamics of Rm changes)

- Tukey's post-hoc test showed a statistically significant difference in the Rm level.
There is a statistically significant decrease in the Rm level with the lapse of the exposure time

Table S6. Results of tensile strength tests of Monocryl sutures in the pancreatic juice (sterile environment).

MONOCRYL											PANCREATIC JUICE - STERILE ENVIRONMENT
Tensile Srength R_m (MPa)	arithmetic average	Median	Min.	Max.	Lower Quartile	Upper Quartile	Standard deviation	Standard Error	Skewness	Kurtosis	Test Shapiro-Wilka

Reference	236.5	238.1	211.6	273.9	217.4	239.8	21.92	8.95	0.8556	1.2525	p = 0,3933
7 days	116.8	118.1	93.1	135.4	109.7	126.3	15.41	6.29	-0.4791	-0.5871	p = 0,6133
14 days	55.8	57.0	49.2	60.2	51.4	59.9	4.69	1.91	-0.5229	-1.8839	p = 0,2516
21 days	9.3	9.2	7.0	11.1	8.4	10.9	1.58	0.64	-0.2313	-0.7770	p = 0,7725

- The ANOVA test showed a statistically significant difference in the Rm level between all exposure times (**p <0.0001**) (i.e. statistically significant dynamics of Rm changes)

- Tukey's post-hoc test showed a statistically significant difference in the Rm level. There is a statistically significant decrease in the Rm level with the lapse of the exposure time

Table S7. Results of tensile strength tests of Monocryl sutures in the bile (sterile environment).

MONOCRYL				**BILE - STERILE ENVIRONMENT**							
Tensile Srength R_m (MPa)	**arithmetic average**	**Median**	**Min.**	**Max.**	**Lower Quartile**	**Upper Quartile**	**Standard deviation**	**Standard Error**	**Skewness**	**Kurtosis**	**Test Shapiro-Wilka**
Reference	236.5	238.1	211.6	273.9	217.4	239.8	21.92	8.95	0.8556	1.2525	p = 0,3933
7 days	123.6	123.2	110.7	136.3	113.5	134.9	10.81	4.41	0.0476	-2.0876	p = 0,4757
14 days	70.8	70.1	64.5	77.9	64.6	77.7	6.50	2.65	0.1331	-2.8810	p = 0,0634
21 days	16.6	16.2	13.1	20.9	14.9	19.1	2.64	1.00	0.4992	-0.2815	p = 0,8814

Table S8. Results of tensile strength tests of Vicryl sutures in saline (sterile environment).

VICRYL				**SALINE - STERILE ENVIRONMENT**							
Tensile Srength R_m (MPa)	**arithmetic average**	**Median**	**Min.**	**Max.**	**Lower Quartile**	**Upper Quartile**	**Standard deviation**	**Standard Error**	**Skewness**	**Kurtosis**	**Test Shapiro-Wilka**
Reference	293.0	305.8	238.9	320.2	281.0	306.3	29.37	11.99	-1.5789	2.4181	p = 0,0864
7 days	252.6	241.5	208.3	309.1	210.7	304.2	44.63	18.22	0.5106	-1.9478	p = 0,1885
14 days	208.0	205.3	171.3	241.3	190.0	234.6	28.03	11.44	-0.0329	-1.9912	p = 0,5030
21 days	190.9	189.8	155.3	227.3	157.9	225.2	31.32	12.79	0.0764	-1.9307	p = 0,3138
28 days	63.0	61.5	51.2	77.5	54.0	72.0	10.96	4.47	0.2573	-2.2627	p = 0,3284

- The ANOVA test showed a statistically significant difference in the Rm level between all exposure times (**p <0.0001**) (i.e. statistically significant dynamics of Rm changes)

- Tukey's post-hoc test showed a statistically significant difference in the Rm level:
  - reference vs day 14 (decrease)
  - reference vs day 21 (decrease)
  - reference vs day 28 (decrease)
  - between day 7 and 21 (decrease)
  - between day 7 vs 28 (decrease)
  - between day 14 and day 28 (decrease)
  - between day 21 and day 28 (decrease)

Table S9. Results of tensile strength tests of Vicryl sutures in the pancreatic juice (sterile environment).

VICRYL	PANCREATIC JUICE - STERILE ENVIRONMENT										
Tensile Srength R_m (MPa)	arithmetic average	Median	Min.	Max.	Lower Quartile	Upper Quartile	Standard deviation	Standard Error	Skewness	Kurtosis	Test Shapiro-Wilka
Reference	293.0	305.8	238.9	320.2	281.0	306.3	29.37	11.99	-1.5789	2.4181	p = 0,0864
7 days	240.4	239.2	194.2	284.0	215.7	270.2	36.18	14.77	-0.0527	-2.2352	p = 0,4051
14 days	172.4	177.6	141.7	194.0	153.9	190.0	21.60	8.82	-0.4913	-1.7993	p = 0,4291
21 days	93.7	89.1	77.9	123.7	82.6	99.8	16.43	6.71	1.4597	2.2465	p = 0,2248

- The ANOVA test showed a statistically significant difference in the Rm level between all exposure times (**p <0.0001**) (i.e. statistically significant dynamics of Rm changes)

- Tukey's post-hoc test showed a statistically significant difference in the Rm level. There is a statistically significant decrease in the Rm level with the lapse of the exposure time

Table S10. Results of tensile strength tests of Vicryl sutures in the bile (sterile environment).

VICRYL	BILE - STERILE ENVIRONMENT										
Tensile Srength R_m (MPa)	arithmetic average	Median	Min.	Max.	Lower Quartile	Upper Quartile	Standard deviation	Standard Error	Skewness	Kurtosis	Test Shapiro-Wilka
Reference	293.0	305.8	238.9	320.2	281.0	306.3	29.37	11.99	-1.5789	2.4181	p = 0,0864
7 days	290.7	310.2	186.9	353.0	233.4	350.7	66.96	27.33	-0.8282	-0.8336	p = 0,3065
14 days	206.7	210.3	177.0	240.2	177.7	224.9	26.73	10.91	-0.0477	-2.1963	p = 0,3016
21 days	123.3	125.0	105.1	138.5	118.2	128.2	11.12	4.54	-0.5664	1.3050	p = 0,7695
28 days	19.9	19.7	16.3	23.7	18.9	21.2	2.49	1.02	0.1838	0.7397	p = 0,9617

- The ANOVA test showed a statistically significant difference in the Rm level between all exposure times (**p <0.0001**) (i.e. statistically significant dynamics of Rm changes)

- Tukey's post-hoc test showed a statistically significant difference in the Rm level:
  - reference vs day 14 (decrease)
  - reference vs day 21 (decrease)
  - reference vs day 28 (decrease)
  - between day 7 and 14 (decrease)
  - between day 7 and 21 (decrease)
  - between day 7 vs 28 (decrease)
  - between day 14 and day 21 (decrease)
  - between day 14 and day 28 (decrease)
  - between day 21 and day 28 (decrease)

Table S11. Results of tensile strength tests of PDS sutures in saline (sterile environment).

PDS	SALINE - STERILE ENVIRONMENT										
Tensile Srength R_m (MPa)	arithmetic average	Median	Min.	Max.	Lower Quartile	Upper Quartile	Standard deviation	Standard Error	Skewness	Kurtosis	Test Shapiro-Wilka
Reference	117.2	112.7	109.6	132.5	110.5	125.0	9.38	3.83	1.1627	-0.3114	p = 0,0727
7 days	108.1	106.4	97.9	120.1	103.0	114.8	8.07	3.30	0.4719	-0.5460	p = 0,8243
14 days	113.2	113.9	103.5	122.9	105.0	120.1	7.86	3.21	-0.1343	-1.7220	p = 0,6043
21 days	99.2	96.0	87.5	115.9	95.6	104.3	9.75	3.98	0.9912	1.2698	p = 0,3986
28 days	98.3	96.1	91.0	112.1	94.3	99.9	7.36	3.00	1.6439	3.1938	p = 0,1434

- The ANOVA test showed a statistically significant difference in the Rm level between all exposure times (**p = 0.0019**) (i.e. statistically significant dynamics of Rm changes)

- Tukey's post-hoc test showed a statistically significant difference in the Rm level:
  - between day 14 vs 21 days (decrease)
  - between day 14 and 28 (decrease)
  - reference vs day 21 (decrease)
  - reference vs day 28 (decrease)

Table S12. Results of tensile strength tests of PDS sutures in the pancreatic juice (sterile environment).

PDS	PANCREATIC JUICE - STERILE ENVIRONMENT										
Tensile Srength R_m (MPa)	arithmetic average	Median	Min.	Max.	Lower Quartile	Upper Quartile	Standard deviation	Standard Error	Skewness	Kurtosis	Test Shapiro-Wilka
Reference	117.2	112.7	109.6	132.5	110.5	125.0	9.38	3.83	1.1627	-0.3114	p = 0,0727
7 days	100.7	100.9	82.7	113.5	97.0	109.4	10.92	4.46	-0.7265	0.5522	p = 0,7639
14 days	88.4	87.8	72.8	111.3	76.0	94.5	13.88	5.67	0.7441	0.5895	p = 0,6358
21 days	87.4	88.3	77.0	102.7	77.1	91.2	9.66	3.94	0.4660	0.0535	p = 0,4539
28 days	49.3	51.5	38.0	53.4	48.9	52.4	5.75	2.35	-2.06436	1.4503	p = 0,0632

- The ANOVA test showed a statistically significant difference in the Rm level between all exposure times (**p <0.0001**) (i.e. statistically significant dynamics of Rm changes)

- Tukey's post-hoc test showed a statistically significant difference in the Rm level:
  - reference vs day 14 (decrease)
  - reference vs day 21 (decrease)
  - reference vs day 28 (decrease)
  - between day 7 and 28 (decrease)
  - between day 14 and day 28 (decrease)
  - between day 21 and day 28 (decrease)

Table S13. Results of tensile strength tests of PDS sutures in the bile (sterile environment).

PDS	BILE - STERILE ENVIRONMENT										
Tensile Srength R_m (MPa)	arithmetic average	Median	Min.	Max.	Lower Quartile	Upper Quartile	Standard deviation	Standard Error	Skewness	Kurtosis	Test Shapiro-Wilka
Reference	117.2	112.7	109.6	132.5	110.5	125.0	9.38	3.83	1.1627	-0.3114	p = 0,0727
7 days	117.7	113.3	108.1	139.2	109.0	123.5	11.92	4.87	1.4576	1.6984	p = 0,1309
14 days	116.4	115.6	112.3	123.5	114.9	116.4	3.77	1.54	1.5813	3.5622	p = 0,1225
21 days	115.7	116.7	106.9	121.1	111.6	121.0	5.56	2.27	-0.7624	-0.4164	p = 0,4624
28 days	103.6	104.0	96.8	109.4	98.3	108.7	5.20	2.12	-0.2311	-1.7292	p = 0,4623

- The ANOVA test showed a statistically significant difference in the Rm level between all exposure times (**p <0.0001**) (i.e. statistically significant dynamics of Rm changes)

- Tukey's post-hoc test showed a statistically significant difference in the Rm level:
  - reference vs day 28 (decrease)
  - between day 7 and 28 (decrease)

3. EVALUATION OF THE INFLUENCE OF THE EXPOSURE TIME ON THE TENSILE STRENGTH (Rm) - CONTAMINATED ENVIRONMENT

Table S14. Results of tensile strength tests of Monocryl sutures in the pancreatic juice (infected environment).

MONOCRYL	PANCREATIC JUICE - CONTAMINATED ENVIRONMENT										
Tensile Srength R_m (MPa)	arithmetic average	Median	Min.	Max.	Lower Quartile	Upper Quartile	Standard deviation	Standard Error	Skewness	Kurtosis	Test Shapiro-Wilka
Reference	236.5	238.1	211.6	273.9	217.4	239.8	21.92	8.95	0.8556	1.2525	p = 0,3933
7 days	116.3	119.0	91.6	132.7	112.1	123.5	14.04	5.73	-1.0940	1.7923	p = 0,5525
14 days	26.4	26.3	21.2	32.6	22.3	29.5	4.33	1.77	0.2563	-1.0115	p = 0,8788
21 days	5.0	5.1	3.8	6.1	4.6	5.5	0.79	0.32	-0.4306	0.5014	p = 0,9516
28 days	236.5	238.1	211.6	273.9	217.4	239.8	21.92	8.95	0.8556	1.2525	p = 0,3933

- The ANOVA test showed a statistically significant difference in the Rm level between all exposure times (**p <0.0001**) (i.e. statistically significant dynamics of Rm changes)

- There is a statistically significant decrease in the Rm level with the lapse of the exposure time.

Table S15. Results of tensile strength tests of Monocryl sutures in the bile (infected environment).

MONOCRYL	BILE - CONTAMINATED ENVIRONMENT										
Tensile Srength R_m (MPa)	arithmetic average	Median	Min.	Max.	Lower Quartile	Upper Quartile	Standard deviation	Standard Error	Skewness	Kurtosis	Test Shapiro-Wilka
Reference	236.5	238.1	211.6	273.9	217.4	239.8	21.92	8.95	0.8556	1.2525	p = 0,3933
7 days	109.7	114.1	88.5	120.1	105.0	116.3	11.55	4.71	-1.5425	2.2581	p = 0,1525
14 days	66.1	67.4	54.6	76.2	60.5	70.7	7.69	3.14	-0.3814	-0.3109	p = 0,9633
21 days	13.1	13.5	10.8	15.2	12.0	13.8	1.52	0.62	-0.3588	-0.0376	p = 0,8607
28 days	236.5	238.1	211.6	273.9	217.4	239.8	21.92	8.95	0.8556	1.2525	p = 0,3933

- The ANOVA test showed a statistically significant difference in the Rm level between all exposure times (**p <0.0001**) (i.e. statistically significant dynamics of Rm changes)

- There is a statistically significant decrease in the Rm level with the lapse of the exposure time.

Table S16. Results of tensile strength tests of Vicryl sutures in the pancreatic juice (infected environment).

VICRYL	PANCREATIC JUICE - CONTAMINATED ENVIRONMENT										
Tensile Srength R_m (MPa)	arithmetic average	Median	Min.	Max.	Lower Quartile	Upper Quartile	Standard deviation	Standard Error	Skewness	Kurtosis	Test Shapiro-Wilka
Reference	293.0	305.8	238.9	320.2	281.0	306.3	29.37	11.99	-1.5789	2.4181	p = 0,0864
7 days	161.8	158.3	148.6	184.2	150.6	170.6	13.41	5.47	1.0141	0.2962	p = 0,3711
14 days	53.0	56.5	42.8	59.1	44.2	58.9	7.60	3.10	-0.7822	-1.9102	p = 0,0511
21 days	15.4	14.8	12.6	18.8	13.3	18.1	2.54	1.04	0.4784	-1.6721	p = 0,4541
28 days	293.0	305.8	238.9	320.2	281.0	306.3	29.37	11.99	-1.5789	2.4181	p = 0,0864

- The ANOVA test showed a statistically significant difference in the Rm level between all exposure times (**p <0.0001**) (i.e. statistically significant dynamics of Rm changes)

- There is a statistically significant decrease in the Rm level with the lapse of the exposure time.

Table S17. Results of tensile strength tests of Vicryl sutures in the bile (infected environment).

VICRYL	BILE - CONTAMINATED ENVIRONMENT										
Tensile Srength R_m (MPa)	arithmetic average	Median	Min.	Max.	Lower Quartile	Upper Quartile	Standard deviation	Standard Error	Skewness	Kurtosis	Test Shapiro-Wilka
Reference	293.0	305.8	238.9	320.2	281.0	306.3	29.37	11.99	-1.5789	2.4181	p = 0,0864
7 days	217.9	224.9	175.6	234.9	214.1	233.1	22.44	9.16	-1.7119	3.0561	p = 0,0506
14 days	159.0	160.9	110.1	200.9	128.5	192.9	35.31	14.42	-0.2272	-1.3036	p = 0,6397
21 days	42.8	43.9	35.5	45.9	42.3	45.5	3.81	1.55	-1.8598	3.7601	p = 0,0528
28 days	293.0	305.8	238.9	320.2	281.0	306.3	29.37	11.99	-1.5789	2.4181	p = 0,0864

- The ANOVA test showed a statistically significant difference in the Rm level between all exposure times (**p <0.0001**) (i.e. statistically significant dynamics of Rm changes)

- There is a statistically significant decrease in the Rm level with the lapse of the exposure time.

Table S18. Results of tensile strength tests of PDS sutures in the pancreatic juice (infected environment).

PDS	PANCREATIC JUICE - CONTAMINATED ENVIRONMENT										
Tensile Srength R_m (MPa)	arithmetic average	Median	Min.	Max.	Lower Quartile	Upper Quartile	Standard deviation	Standard Error	Skewness	Kurtosis	Test Shapiro-Wilka
Reference	117.2	112.7	109.6	132.5	110.5	125.0	9.38	3.83	1.1627	-0.3114	p = 0,0727
7 days	115.3	114.5	107.5	124.4	112.7	118.3	5.67	2.32	0.4601	0.9354	p = 0,9269
14 days	116.0	113.4	102.6	136.2	111.6	118.7	11.21	4.58	1.2253	2.6110	p = 0,3024
21 days	85.6	87.6	63.2	102.6	76.0	96.9	14.69	6.00	-0.5299	-0.7595	p = 0,8142
28 days	63.6	66.5	47.6	72.2	57.3	71.8	9.94	4.06	-0.8656	-0.4635	p = 0,2137

- The ANOVA test showed a statistically significant difference in the Rm level between all exposure times (**p <0.0001**) (i.e. statistically significant dynamics of Rm changes)
- Tukey's post-hoc test showed a statistically significant difference in the Rm level:

- reference vs day 21 (decrease)
- reference vs day 28 (decrease)
- between day 7 and 21 (decrease)
- between day 7 and 28 (decrease)
- between day 14 and day 21 (decrease)
- between day 14 and day 28 (decrease)
- between day 21 and day 28 (decrease)

Table S19. Results of tensile strength tests of PDS sutures in the bile (infected environment).

PDS	BILE - CONTAMINATED ENVIRONMENT										
Tensile Srength R_m (MPa)	arithmetic average	Median	Min.	Max.	Lower Quartile	Upper Quartile	Standard deviation	Standard Error	Skewness	Kurtosis	Test Shapiro-Wilka
Reference	117.2	112.7	109.6	132.5	110.5	125.0	9.38	3.83	1.1627	-0.3114	p = 0,0727
7 days	119.2	119.5	104.2	131.2	112.3	128.7	10.72	4.38	-0.2672	-1.7861	p = 0,5072
14 days	120.2	121.2	114.3	123.6	117.9	123.0	3.65	1.49	-0.8639	-0.3862	p = 0,3349
21 days	106.7	106.4	97.7	113.9	106.0	109.9	5.36	2.19	-0.6538	1.7161	p = 0,5139
28 days	102.3	106.1	87.9	111.1	95.4	107.3	8.81	3.60	-1.0745	-0.0760	p = 0,2089

- The ANOVA test showed a statistically significant difference in the Rm level between all exposure times (**p=0,0014**) (i.e. statistically significant dynamics of Rm changes)

- Tukey's post-hoc test showed a statistically significant difference in the Rm level:

- reference vs day 21 (decrease)
- reference vs day 28 (decrease)
- between day 7 and 21 (decrease)
- between day 7 and 28 (decrease)
- between day 14 and day 21 (decrease)
- between day 14 and day 28 (decrease)