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АЛЛЕРГИЧЕСКИЙ РИНИТ, ОБУСЛОВЛЕННЫЙ СЕНСИБИЛИЗАЦИЕЙ К ПЫЛЬЦЕ СОРНЫХ ТРАВ: КЛИНИКО-ЛАБОРАТОРНАЯ ХАРАКТЕРИСТИКА

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Abstract

11.7% of patients with sensitization to weed pollen were found to have a severe course of allergic rhinitis; 73.3% had a moderate course, while another 15% featured a mild course of the disease.

Skin tests identified 20% of cases with monosensitization to ragweed allergens, 20% of cases with oligosensitization to ragweed and wormwood allergens, and 60% of cases involving polysensitization to pollen of weeds, trees, and meadow grass. An allergological test based on component-separated molecular allergy diagnostics revealed predominant sensitization to nAmb a1, which is the major ragweed allergen.

Аннотация

У 11,7% пациентов, сенсибилизированных к пыльце сорных трав, наблюдается тяжелое течение АР, у 73,3% – среднетяжелое, у 15% – легкое течение заболевания. При выполнении кожных проб в 20% случаев выявляется моносенсибилизация к аллергенам амброзии, в 20% –олигосенсибилизация к аллергенам амброзии и полыни, в 60% – полисенсибилизация к пыльце сорняков, деревьев, луговых трав. При аллергологическом обследовании методом компонент-разделенной молекулярной аллергодиагностики выявляется преимущественная сенсибилизация к мажорному аллергену амброзии – nAmb a1.

Keywords: pollinosis, weeds, clinical pattern, molecular allergy diagnostics
Ключевые слова: поллиноз, сорные травы, клиническая картина, молекулярная аллергодиагностика

В течение последних 50-ти лет наблюдается прогрессивное глобальное увеличение бремени аллергических заболеваний в промышленно развитых странах мира [1]. Статистические данные многих стран свидетельствуют о возрастании частоты и распространенности респираторных аллергических заболеваний, таких как аллергический ринит и бронхиальная астма [2]. От 10 до 15% населения земного шара страдает поллинозом с ежегодным приростом числа заболевших на 3-4% [3], что обусловлено не только загрязнением воздуха и изменением образа жизни, но и изменением климата, увеличением количества и аллергенности пыльцы [4]. В странах Европы распространенность пыльцевой сенсибилизации достигает 30-40% [4, 5], в Российской Федерации колеблется в диапазоне от 12,7 до 38% [6].

Цель исследования: оценить клинико-иммунологические особенности поллиноза у пациентов, сенсибилизированных пыльцой сорных трав

Материал и методы исследования. Клинические, инструментальные и лабораторные исследования выполнялись в АНМО «Ставропольский клинический клинико-диагностический центр» и включали анализ аллергологического анамнеза, клинический осмотр, определение степени тяжести аллергического ринита, переднюю риноскопию, при необходимости – рентгенологическое исследование околоносовых пазух, компьютерную томографию и эндоскопическое исследование полости носа и околоносовых пазух.

При оценке клинических данных применяли шкалу RTSS (Rhinoconjunctivitis total symptom score) (Shamji M.H. et al., 2017) [7]. **В дневниках самонаблюдения пациенты ежедневно регистрировали интенсивность клинических симптомов поллиноза, сведения о принимаемых лекарственных препаратах. Врач анализировал 6 клинических признаков заболевания – затруднение носового дыхания, чихание, ринорею, зуд в полости носа, слезотечение, зуд глаз. Применялась балльная шкала RTSS: отсутствие признака – 0 баллов, минимальная выраженность симптомов – 1 балл, умеренная – 2 балла, максимально высокая – 3 балла. Количество баллов за сутки колебалось в пределах от 0 до 18.**

Учет лекарственной терапии проводился с использованием шкалы dMS (Daily medication

score) (Pfaar O. et al., 2015) [8] по схеме: отсутствие приема лекарственных средств – 0 баллов, системные или топические антигистаминные препараты или блокаторы лейкотриеновых рецепторов – 1 балл, интраназальные топические ГКС в качестве монотерапии или в комбинации с топическими или системными антигистаминными или антилейкотриеновыми препаратами – 2 балла, системные глюкокортикоиды, как монотерапия или в сочетании с топическими или системными антигистаминными средствами или блокаторами антилейкотриеновых рецепторов – 3 балла. Количество баллов за сутки составляло от 0 до 3-х.

Для накожного тестирования (Prick-тесты) применяли 3-5% водные растворы стандартных пыльцевых аллергенов (ФГУП НПО «Микроген», Ставрополь). При постановке кожных проб у 12 (20%) пациентов выявлена моносенсибилизация к пыльце амброзии, у 12 (20%) – олигосенсибилизация к амброзии и полыни, у 12 (20%) – полисенсибилизация к сорным травам – полыни, амброзии, подсолнечнику, лебеде, циклахене, у 17 (28,3%) – к сорным травам и тимофеевке, у 7 (11,7%) – к сорным травам и березе.

Уровень специфических IgE к мажорным и минорным аллергенам пыльцы деревьев, луговых и сорных трав исследовали методом непрямой иммунофлуоресценции ImmunoCap с использованием тест-системы Phadiatop на иммунохемилюминисцентном анализаторе Phadia 100, Швеция, который рекомендуется как золотой стандарт аллергодиагностики Всемирной Организацией Здравоохранения и FDA США (Food and Drug Administration) [9].

Результаты и их обсуждение. Обследованы 60 больных с аллергическим ринитом (22 женщины, 38 мужчин), сенсибилизированных к пыльце сорных трав в возрасте от 16 до 55 лет (таблица), средний возраст составил 23,03±1,22 года. **В 68,3% случаев в структуре коморбидной патологии диагностировались аллергический конъюнктивит, в 16,7%** – бронхиальная астма, в 11,7% – пищевая аллергия, в 26,7% – атопический дерматит.

При выполнении Prick-тестов у 12 (20%) больных установлена моносенсибилизация к аллергенам амброзии, у 12 (20%) – олигосенсибилизация к пыльце амброзии и полыни, у 12 (20%) – полисенсибилизация к пыльце сорняков – полыни, амброзии, подсолнечнику, лебеде, циклахене, у 17 (28,3%) – к аллергенам сорных травам и тимофеевке, у 7 (11,7%) – к аллергенам сорняков и деревьев.

Легкое течение аллергического ринита отмечено у 15% больных, среднетяжелое – у 73,3%, тяжелое – у 11,7%. **В 68,3% случаев в структуре коморбидной патологии диагностировались аллергический конъюнктивит, в 16,7%** – бронхиальная астма, в 11,7% – пищевая аллергия, в 26,7% – атопический дерматит.

Таблица – Клиническая характеристика пациентов с аллергическим ринитом, сенсибилизированных к пыльце сорных трав

Показатель	Значение
Возраст, лет	23,03±1,22
Гендерный состав м/ж	22/38
Легкое течение, %	15,0
Среднетяжелое течение, %	73,3
Тяжелое течение, %	11,7
Длительность обострений, дни	51,2±2,35
Конъюнктивит, %	68,3
Аллергическая БА, %	16,7
Пищевая аллергия, %	11,7
Атопический дерматит, %	26,7
RTSS, баллы	13 [10; 15]
dMS, баллы	2 [2; 2]
IgE общий, МЕ/мл	**331 [149; 605,5]**
IgE спец. nAmb a1, кЕ/л	**41,9 [1,62; 71,4]**
IgE спец. nArt v1, кЕ/л	**1,25 [0,01; 3,89]**

Пищевая аллергия встречалась у 1 (8,3%) пациента в группе I, у 2 (16,6%) в группе II и у 4 (11,1%) в группе III и была представлена преимущественно оральным аллергическим синдромом. У 4-х пациентов, сенсибилизированных к аллергенам березы, отмечалась аллергическая реакция на косточковые (яблоко, груша, вишня), у 2-х пациентов с олигосенсибилизацией к амброзии и полыни – на сельдерей и морковь, у пациента с моносенсибилизацией к амброзии сформировалась cross-реакция на рыбу.

Аллергическая бронхиальная астма манифестировала в возрасте до 14 лет, 9 из 10 пациентов имели не более 1-2 обострений в год и получали SMART-терапию будесонид/формотерол в низкой дозе по потребности. У одного пациента с поливалентной сенсибилизацией применялась базисная терапия ИГКС в низкой дозе.

Специфические IgE методом ImmunoCAP к nAmb a1 (мажорный аллерген амброзии) определены у 81,7% больных, к nArt v1 (мажорный аллерген полыни) – у 26,7%, к rPhl p1,5 (мажорные ал-

лергены тимофеевки) – у 10,0%, к rPhl p7,12 (минорные аллергены луговых трав) – у 18,3%, к Bet v1 (мажорный аллерген березы) – у 6,7%, к Bet v2, 4 (минорные аллергены деревьев) – у 10,0%.

При определении средних показателей отмечались высокие уровни общего IgE (**331 [149; 605,5] МЕ/мл)**, очень высокие специфические IgE к мажорному аллергену амброзии nAmb a1 (**41,9 [1,62; 71,4] кЕ/л).** Средний уровень специфического IgE к мажорному аллергену полыни у пациентов, сенсибилизированных к сорнякам, был относительно невысоким (0,58 МЕ/мл [0,05; 3,8]), что обусловлено более частым формированием гиперчувствительности к амброзии у жителей Юга России.

Медиана количества баллов по визуально-аналоговой шкале RTSS у пациентов, сенсибилизированных к пыльце сорняков, достигала 13 [10; 15] баллов, по шкале, оценивающей объем лекарственной терапии, dMS – 2 [2; 2].

Таким образом, легкое течение аллергического ринита отмечено у 15% больных, сенсибилизированных к пыльце сорных трав, среднетяжелое – у 73,3%, тяжелое – у 11,7%. В 20% случаев по результатам кожных проб установлена моносенсибилизация к пыльце амброзии, 20% – олигосенсибилизация к амброзии и полыни, 20% – полисенсибилизация к сорным травам – полыни, амброзии, подсолнечнику, лебеде, циклахене, 28,3% – к сорным травам и тимофеевке, 11,7% – к сорным травам и березе. При аллергологическом обследовании «in vitro» у сенсибилизированных к пыльце сорняков определяется преимущественная сенсибилизация к мажорному аллергену амброзии – nAmb a1.

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IMPACT OF METEOROLOGICAL AND GEOMAGNETIC FACTORS ON CARDIOVASCULAR SYSTEM

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ВЛИЯНИЕ МЕТЕОРОЛОГИЧЕСКИХ И ГЕОМАГНИТНЫХ ФАКТОРОВ НА СЕРДЕЧНО-СОСУДИСТУЮ СИСТЕМУ

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Abstract

The article is devoted to the problem of earth and cosmic weather influence on the cardiovascular system in people, including patients with arterial blood pressure and ischemic heart disease. Basic chapters are dedicated to results of own investigation in estimation of correlation between weather factors and hemodynamic parameters, taking into account the drug with adaptogen action-melatonin, possessing by meteorological and geomagnetic activity.

Аннотация

Влияние погодных условий на человека является поводом для тщательного изучения реакций, формирующихся в ответ на действие метеорологических факторов, и создания защиты от метеотропных реакций. Значительные атмосферные изменения могут вызвать перенапряжение и срыв механизмов адаптации. Тогда колебательные процессы в организме - биологические ритмы, искажаются, становятся хаотичными. Патологическая (болезненная) погодная реакция представляет своего рода «бурю» в организме (кузнецова ю.а., 2009). Способствуют её развитию нарушения регуляции вегетативной нервной системы. На организм влияет как погода в целом, так и отдельные её компоненты. Колебания барометрического давления действуют 2-мя путями: снижают насыщение крови кислородом (эффект барометрических «ям») и механически раздражают рецепторы плевры, брюшины, синовиальной оболочки суставов, а также рецепторы сосудов. Ветер вызывает перевозбуждение нервной системы, раздражая рецепторы кожи. Влажность воздуха играет роль в поддержании плотности кислорода в атмосфере влияет на тепловой обмен и потоотделение. В результате современных исследований выявлено важное значение гелиогеофизических факторов в сочетании с генетической конституцией в формировании биоритмов живых систем (бреус т.к. с соавт., 2005; букалов а.в., 2004). Сердечно-сосудистая система является одной из наиболее чувствительных систем организма к гелиогеофизическим факторам, во многом определяющей специфику, выраженность и направленность компенсаторно-приспособительных реакций к факторам среды. Установлено, что больные артериальной гипертонией (аг) с недостаточным уровнем снижения артериального давления (ад) в ночные часы (non-dippers) отличаются большей величиной корреляций с более высокими значениями показателей сад, дад, пад со степенью гипертрофии миокарда, индексом массы тела, показателями углеводного и холестеринового обмена, ассоциацией с гелиогеофизической динамикой на момент проведения исследования. Вариабельность сердечного ритма и реологические свойства крови - основные показатели, на которые воздействуют факторы геомагнитной активности. Установлено, что здоровые люди не имеют эффектов как метео-, так и магниточувствительности (zenchenko t.a. et al., 2009). Среди больных с аг эффекты погоды и геомагнитной активности выражены в равной степени - распределения статистически не отличаются. У больных с аг максимальная корреляция с геомагнитной активностью наблюдается при запаздывании изменений ад относительно kp-индекса геомагнитной активности на 2-е сутки. Подобное запаздывание эффекта геомагнитной активности во время магнитных бурь наблюдалось практически и в предыдущих исследованиях. Определялась чувствительность организма к влиянию космических излучений, в частности солнечного ветра, и индуцируемых им магнитных бурь в диапазоне самых различных частот, особенно сверхнизких (chibisov s.m., 2003). Изучение влияния на сердечно-сосудистую систему всех возможных видов геомагнитных возмущений, генерированных солнечной активностью, свидетельствует о развитии «сбоев» биологических часов. Также установлено, что геомагнитные бури оказывают определенное воздействие на вегетативную нервную систему и регуляцию сердечного ритма и сосудистого тонуса у всех людей. Серьёзные последствия воздействия магнитных бурь могут наблюдаться в основном у больных, перенесших инфаркт миокарда и у лиц, находящихся в состоянии значительного дополнительного стресса.

Keywords: *meteorological and geomagnetic factors, weather condition, meteo - and magnetosensitive patients, melatonin, correlation relation.*

Ключевые слова: *метеорологические и геомагнитные факторы, погодные условия, метео- и магниточувствительные больные, мелатонин, корреляционные отношения.*

МАТЕРИАЛ И МЕТОДЫ

С учётом цели и задач настоящего исследования в работе была проведена оценка влияния погодных факторов: температуры воздуха, атмосферного давления, относительной влажности, точки росы, облачности, направления и скорости ветра, а также геомагнитной активности на состояние сердечно-сосудистой системы. В качестве индекса геомагнитной активности были использованы суточные значения планетарных индексов (сумма 3-часовых

значений Кр-индекса). Корреляционному анализу подверглись показатели самоконтроля АД в утренние и вечерние часы, параметры СМАД, ЭхоКГ до и после проводимых курсов лечения, и погодные факторы во время измерения, накануне исследования, на следующий день, а также с учётом перепада параметров погоды. Величины метеофакторов получали из сервера «Погода России» (meteo.info.space.ru). Уровень значимости при проведении корреляционного анализа - 95% ($p<0.05$)

Нами были обследованы 74 пациентов (средний возраст составил 54,2±1,6 года) с разным уровнем АД, в том числе с АГ 2-3 стадии, 2-3 степени. Длительность заболевания составила в среднем 10.1±1,8 лет. Для верификации диагноза эссенциальной АГ использовали рекомендации экспертов ВОЗ (1999). Из 74 больных были выделены 2 группы. 1-я-группа состояла из 38 пациентов (средний возраст 58,6 ±1,5лет). Длительность заболевания колебалась от 1 до 11 лет. Среди них было 23 женщин и 15 мужчин. В эту группу входили 29 больных стенокардией и 9 - с постинфарктным кардиосклерозом. Функциональный класс ХСН 1 стадии имелся у 10 больных, ХСН 2-й стадии - у 13 больных, ХСН 3- й стадии - у 6. Традиционная терапия (ТТ) включала гипотензивные и антиангинальные препараты: антагонисты кальция, бета-адреноблокаторы, ингибиторы АПФ, диуретики антиагреганты, нитраты. При поступлении в стационар исследовали общепринятые клинико-инструментально-лабораторные тесты: САД (систолическое артериальное давление) и ДАД (диастолическое артериальное давление), АДср (среднее давление), ПАД (пульсовое давление), ЧСС (частота сердечных сокращений), ДП (двойное произведение), ЭКГ, ЭХОКГ, СМАД, клинический и биохимический анализы крови, коагулограмму, определяли корреляционные отношения между погодными факторами и параметрами гемодинамики. ДП вычисляли по формуле:

ДП = (САД х ЧСС) / 100.

Подчеркнем, что при анализе воздействия факторов погоды на показатели гемодинамики далеко не всегда речь идет о непосредственном, прямом влиянии погодных факторов на гемодинамику человека. Вряд ли такие погодные факторы как точка росы, облачность или направление ветра оказывают прямое влияние на физиологические процессы. В данном случае стоит предположить наличие скрытых атмосферных факторов, которые одновременно влияют на формирование соответственных погодных величин и на физиологические процессы человека.

Отметим, кроме этого, что корреляционному анализу подвергались не только непосредственные значения погодных факторов, но и их некоторые производные показатели, прежде всего разности (перепады) погодных показателей, в предположении, что эти перепады могут сильнее влиять на гемодинамику человека, чем результаты непосредственных измерений. Кроме того, проводилось не только непосредственное сравнение временных рядов, но и сдвиги их относительно друг друга т.е. анализировалось также запаздывания и опережения.

РЕЗУЛЬТАТЫ

КОРРЕЛЯЦИОННЫЕ СВЯЗИ МЕЖДУ ФАКТОРАМИ ПОГОДЫ И ПОКАЗАТЕЛЯМИ ГЕМОДИНАМИКИ У БОЛЬНЫХ С АРТЕРИАЛЬНОЙ ГИПЕРТЕНЗИЕЙ И ИШЕМИЧЕСКОЙ БОЛЕЗНЬЮ СЕРДЦА, ПОЛУЧАЮЩИХ КОМПЛЕКСНУЮ ТРАДИЦИОННУЮ ТЕРАПИЮ (ТТ).

На протяжении всего периода наблюдения показатели САД, ДАД, ПАД, АДСР, ДП, ЧСС измеряли в утренние (9.00) и вечерние (19.00) часы. Затем была проведена оценка влияния метеорологических и геомагнитных факторов на показатели гемодинамики - проведен корреляционный анализ. У пациентов этой группы между данными показателями выявлено 180 значимых корреляций. Таблицы 1 и 2.

Таблица 1.

Корреляционные отношения между показателями гемодинамики (САД, ДАД, ЧСС) и факторам погоды у больных АГ и ИБС, получавших традиционную терапию (ТТ).

	САД утром	**ДАД утром**	**ЧСС утром**	**САД вечером**	**ДАД вечером**	**ЧСС вечером**
Атмосферное давление:						
-в момент измерения	-0,193 (p<0,01)	-0,148 (p<0,05)	0,328 (p<0,001)	-0,153 (p<0,04)		0,323 (p<0,001)
-накануне исследования	-	-	0,384 (p<0,001)	-		0,384 (p<0,001)
-на следующий день	-0,230 (p<0,003)	-0,177 (p<0,02)	0,253 (p<0,001)	-0,220 (p<0,004)		0,246 (p<0,001)
Температура:						
-в момент измерения	0,419 (p<0,001)	0,244 (p<0,002)	-0,286 (p<0,001)			-0,300 (p<0,001)
-накануне исследования	0,407 (p<0,001)	0,246 (p<0,001)	-0,305 (p<0,001)			-0,319 (p<0,001)
-на следующий день	0,424 (p<0,001)	0,250 (p<0,001)	-0,265 (p<0,001)			-0,284 (p<0,001)

Относительная влажность: -в момент измерения -накануне исследования -на следующий день -перепад			-0,457 (p<0,001) -0,480 (p<0,001) -0,462 (p<0,001) -	- - - 0,154 (p<0,04)		-0,471 (p<0,001) -0,492 (p<0,001) -0,475 (p<0,001) -
Точка росы: -в момент измерения -накануне исследования -на следующий день	0,354 (p<0,001) 0,335 (p<0,001) 0,378 (p<0,001)	0,288 (p<0,001) 0,284 (p<0,001) 0,288 (p<0,001)	-0,555 (p<0,001) -0,553 (p<0,001) -0,265 (p<0,001)		0,171 (p<0,02) 0,188 (p<0,01) 0,179 (p<0,02)	-0,555 (p<0,001) -0,557 (p<0,001) -0,554 (p<0,001)
Облачность верхняя: -в момент измерения -накануне исследования -на следующий день			- 0,198 (p<0,01) 0,205 (p<0,01)			0,167 (p<0,04) 0,163 (p<0,04) 0,178 (p<0,03)
Направление ветра: -в момент измерения -накануне исследования -на следующий день -перепад			-0,273 (p<0,001) -0,210 (p<0,005) -0,294 (p<0,001) 0,155 (p<0,04)			-0,250 (p<0,001) -0,205 (p<0,006) -0,285 (p<0,001) 0,165 (p<0,03)
Скорость ветра: -в момент измерения -накануне исследования -на следующий день			-0,193 (p<0,01) -0,196 (p<0,009) -0,162 (p<0,03)			-0,149 (p<0,05) -0,174 (p<0,02)
Индекс геомагнитной активности (Кр-индекс): -в момент измерения -накануне исследования -на следующий день -через 2 дня после измерения - через 3 дня после измерения	0,413 (p<0,001) 0,436 (p<0,001) - 0,471 (p<0,001) 0,325 (p<0,001)	0,387 (p<0,001) 0,395 (p<0,001) - 0,374 (p<0,001) -		0,416 (p<0,001) 0,406 (p<0,001) 0,378 (p<0,001) 0,390 (p<0,001) -	0,468 (p<0,001) 0,485 (p<0,001) 0,432 (p<0,001) 0,470 (p<0,001) -	

Таблица 2.

Корреляционные отношения между показателями гемодинамики (ПАД, АДср, ДП) и погодными факторами у больных АГ и ИБС, получавших традиционную терапию

	ПАД утром	**АДср утром**	**ДП утром**	**ПАД вечером**	**АДср вечером**	**ДП вечером**
Атмосферное давление:						
-в момент измерения	-0,155 (p<0,04)	-0,185 (p<0,01)	0,299 (p<0,001)	-	-0,183 (p<0,01)	0,258 (p<0,001)
-накануне исследования	-	-	0,362 (p<0,001)	-	-0,154 (p<0,04)	0,315 (p<0,001)
-на следующий день	-0,216 (p<0,004)	-0,271 (p<0,001)	-	-0,166 (p<0,03)	-0,241 (p<0,002)	-
Температура:						
-в момент измерения	0,390 (p<0,001)	0,358 (p<0,001)	-0,160 (p<0,03)		-	-0,229 (p<0,003)
-накануне исследования	0,373 (p<0,001)	0,353 (p<0,001)	-0,183 (p<0,01)		-	-0,249 (p<0,001)
-на следующий день	0,426 (p<0,001)	0,394 (p<0,001)	-		0,173 (p<0,02)	-0,194 (p<0,001)
Относительная влажность:						
-в момент измерения	-0,159 (p<0,03)		-0,489 (p<0,001)	-		-0,477 (p<0,001)
-накануне исследования	-0,171 (p<0,02)		-0,518 (p<0,001)	-		-0,487 (p<0,001)
-на следующий день	-		-0,477 (p<0,001)	-		-0,481 (p<0,001)
-перепад	-		-	0,161 (p<0,03)		-
Точка росы:						
-в момент измерения	0,272 (p<0,001)	0,348 (p<0,001)	-0,453 (p<0,001)		-	-0,505 (p<0,001)
-накануне исследования	0,248 (p<0,001)	0,336 (p<0,001)	-0,483 (p<0,001)		-	-0,525 (p<0,001)
-на следующий день	0,344 (p<0,001)	0,397 (p<0,001)	-0,409 (p<0,001)		0,149 (p<0,05)	-0,481 (p<0,001)
Облачность верхняя:			-			-
-в момент измерения			0,192 (p<0,02)			-
-накануне исследования			0,239 (p<0,003)			0,198 (p<0,01)
-на следующий день						
Облачность средняя:	-0,198 (p<0,01)					
-в момент измерения	-0,173 (p<0,03)					
-накануне исследования						
Направление ветра:			-0,285 (p<0,001)			-0,227 (p<0,003)
-в момент измерения			-0,225 (p<0,003)			-0,171 (p<0,02)
-накануне исследования			-0,351 (p<0,001)			-0,326 (p<0,001)
-на следующий день			-			0,166 (p<0,03)
-перепад						

Скорость ветра: -в момент измерения -накануне исследования			-0,225 (p<0,003) -0,219 (p<0,004)			- -0,200 (p<0,008)
Индекс геомагнитной активности (Кр-индекс): -в момент измерения -накануне исследования -за 2 дня до измерения -за 3 дня до измерения -на следующий день -через 2 дня после измерения - через 3 дня после измерения	- 0,315 (p<0,001) - - - 0,400 (p<0,001) -	0,512 (p<0,001) 0,555 (p<0,001) - - 0,334 (p<0,001) 0,499 (p<0,001) 0,412 (p<0,001)		- - 0,340 (p<0,001) 0,308 (p<0,001) - - -	- - - - - 0,494 (p<0,001) -	

Наблюдался широкий спектр реакций организма пациентов на воздействие факторов погоды. Характерное время сдвига реакции организма относительно момента измерения метеорологических, а также геомагнитных факторов сильно варьирует и в большинстве случаев соответствует нулевому сдвигу (в момент измерения), следующему дню (запаздывание) или дню накануне исследования (опережение).

Анализ таблиц 1 и 2 показывает, что большинство коэффициентов корреляции свидетельствуют о достаточно слабой связи между показателями гемодинамики и погодными факторами. Слабой в том смысле, что значения корреляционных коэффициентов не являются высокими. Их абсолютная величина практически не превосходит 0,4-0,5, а, в подавляющем большинстве, являются более низкими. Но в ряде случаев эта связь оказывалась, хоть и слабой, но статистически достоверной и именно такая связь обсуждается ниже.

Выявлено несколько пар статистически значимых корреляционных связей между показателями гемодинамики и перепадом погодных факторов. Обнаружены как положительные так и отрицательные корреляционные связи, которые означают разнонаправленность реакции гемодинамики и изменений факторов погоды. Время сдвига реакции организма относительно момента измерения индекса геомагнитной активности варьирует и в большинстве случаев соответствовало запаздыванию на 2 дня.

Отрицательная корреляционная связь между утренним уровнем САД и показателем атмосферного давления приходится на нулевой сдвиг и на запаздывание на 1 день. На утренние значения САД также значимо влияют показатели температуры воздуха в момент измерения, а также накануне исследования и на следующий день. Прямая зависимость между утренним САД с показателями точки росы приходится на нулевой сдвиг, на опережение и на запаздывание на 1 день. На утренние значения САД влияет также состояние геомагнитной активности в момент измерения, накануне измерения, через 2 дня после измерения и через 3 дня после измерения. Обратная зависимость вечернего САД с показателями атмосферного давления, приходится на нулевой сдвиг и на запаздывание на 1 день. Выявлена корреляционная связь между значениями вечернего САД и перепадом относительной влажности. Кроме этого, вечерние показатели САД влияет геомагнитная активность в момент измерения, накануне измерения, на следующий день и через 2 дня после измерения.

Выявлены прямая связь между утренним ДАД и верхней облачностью приходится на момент измерения. Зависимость вечернего ДАД с показателями атмосферного давления приходится на момент измерения, на временное опережение, на запаздывание на 1 день, а также на перепад параметров атмосферного давления. Прямая зависимость между вечерним уровнем ДАД и показателями относительной влажности приходится на момент измерения, на опережение и на запаздывание на 1 день. Параметры утреннего значения ДАД коррелируют с показателями атмосферного давления в момент измерения, накануне исследования и на следующий день. Зависимость вечернего ДАД с показателями атмосферного давления приходится на момент измерения, на временное опережение, на запаздывание на 1 день. Зависимость вечернего ДАД с показателями относительной влажности приходится на момент измерения и на запаздывание на 1 день.

Утренние значения ЧСС наиболее подвержены корреляционным отношениям с метеофакторами. Выявлена обратная зависимость утреннего ЧСС с показателями атмосферного давления, которая приходится на момент измерения, на опережение и на

запаздывание на 1 день. Прямая зависимость утреннего ЧСС с показателями температуры воздуха приходится на момент измерения, на опережение и на запаздывание на 1 день. Аналогично, корреляционная связь между утренним ЧСС и верхней облачностью выявлена накануне исследования. Обратная зависимость утреннего ЧСС с показателями относительной влажности приходится на момент измерения, на опережение и на запаздывание на 1 день. Вечерние значения ЧСС менее подвержены влиянию погоды. Отметим корреляционные связи вечернего ЧСС с показателями атмосферного давления в момент измерения, накануне исследования и на следующий день.

Параметры утреннего ПАД коррелируют с показателями атмосферного давления в момент измерения, накануне исследования, а также с показателями верхней облачности в момент измерения. Прямая зависимость утреннего ПАД с показателями относительной влажности приходится на момент измерения, на опережение и на запаздывание на 1 день. Выявлена прямая связь вечернего ПАД с показателями атмосферного давления, которая приходится на момент измерения, на опережение на 1 день и обратная перепаду этого метеофактора. Слабая, но достоверная прямая зависимость вечернего ПАД с показателями относительной влажности приходится на момент измерения и на моменты опережения и запаздывания на 1 день.

Параметры утреннего АД среднего (АДср) коррелируют с показателями атмосферного давления в момент измерения, а также накануне исследования и на следующий день. Влияние магнитной активности на показатели утреннего АДср выявляется накануне исследования, и на следующий день. Слабая, но достоверная зависимость вечернего АДср с показателями атмосферного давления приходится на момент измерения, на временной сдвиг (опережение), на запаздывание на 1 день, а также на перепад атмосферного давления. Выявлены корреляционные отношения между показателями вечернего АДср и параметрами относительной влажности в день исследования, накануне исследования и на следующий день. Влияние геомагнитной активности на показатели вечернего АДср приходится на 1 день накануне исследования.

Утренние значения двойного произведения (ДП) подвержены влиянию факторов погоды аналогично утренним значениям ЧСС. Выявлены отрицательные корреляционные связи утреннего ДП с атмосферным давлением в момент измерения, накануне исследования, на следующий день, а также с температурой воздуха на следующий день. Вечернее ДП также демонстрировало высокую связь с погодными показателями, но менее сильную чем утреннее ДП.

РЕЗЮМЕ

Итак, пациенты, страдающие АГ 2 - 3 степени в сочетании с ИБС и получающие традиционное гипотензивное и антиангинальное лечение подвержены влиянию многих погодных факторов. Наибольшее влияние на показатели АД оказывают атмосферное давление, температура воздуха, точка росы и геомагнитная активность. Незначительно воздействует на показатели гемодинамики облачность, с параметрами нижней облачности. Корреляционные отношения между ними не выявлены. Наиболее подвержены влиянию погоды показатели ЧСС и ДП, измеренные как в утренние, так и в вечерние часы. В меньшей степени коррелируют с погодными факторами вечерние значения САД, ДАД и ПАД.

КОРРЕЛЯЦИОННЫЕ СВЯЗИ МЕЖДУ ФАКТОРАМИ ПОГОДЫ И ПОКАЗАТЕЛЯМИ ГЕМОДИНАМИКИ У БОЛЬНЫХ С АРТЕРИАЛЬНОЙ ГИПЕРТЕНЗИЕЙ И ИШЕМИЧЕСКОЙ БОЛЕЗНЬЮ СЕРДЦА, ПОЛУЧАЮЩИХ КОМПЛЕКСНУЮ ТЕРАПИЮ С МЕЛАТОНИНОМ.

Вторую группу больных с АД 2-3 степени 2-3 стадии и ИБС, получавшую комплексную терапию с мелатонином, составили 36 пациентов, Среди них были 17 женщин и 19 мужчин (средний возраст 55±1,4 лет). Длительность заболевания колебалась от 4-х до 12 лет (в среднем 9,0±1,4 лет). Риск развития сердечно-сосудистых осложнений был очень высокий - у 36 пациентов. 11 больных страдали стенокардией напряжения, у 8 пациентов был диагностирован постинфарктный кардиосклероз. Течение заболевания осложнилось ХСН 1-й стадии у 15 больных, 2-й стадии – у 18 пациентов. Функциональный класс ХСН1 был у 17, ХСН2 - у 22 больных. Традиционная антиангинальная и гипотензивная терапия включала те же препараты, что и больные 1-й группы, также мелатонин (мелаксен, «Unipharm Inc.», USA) в дозе 3 мг, который принимался пациентами в 22 часа. Тактика клинико-инструментального обследования до и после 3-х недельного лечения с включением мелатонина была аналогичной таковой, изложенной выше. На протяжении всего периода наблюдения показатели САД, ДАД, ПАД, АДср, ДП, ЧСС измеряли в утренние (9.00) и вечерние (19.00) часы. Затем была проведена оценка влияния метеорологических и геомагнитных факторов на показатели. У пациентов этой группы между данными показателями выявлено 84 значимых корреляций. Таблицы 3 и 4.

Таблица 3.

Корреляционные отношения между показателями гемодинамики (САД, ДАД, ЧСС) и погодными факторами у больных АГ и ИБС, получающих ТТ с мелатонином.

	САД утром		**ДАД утром**	**ЧСС утром**	**САД вечером**	**ДАД вечером**	**ЧСС вечером**
Атмосферное давление: -в момент измерения -накануне исследования -на следующий день -перепад	0,249 (p<0,001) 0,288 (p<0,001) 0,197 (p<0,005) -		0,177 (p<0,01) 0,191 (p<0,006) 0,182 (p<0,009) -	-0,311 (p<0,001) -0,307 (p<0,001) -0,323 (p<0,001) -	0,205 (p<0,004) 0,224 (p<0,002) 0,187 (p<0,007) -0,152 (p<0,03)	0,248 (p<0,001) 0,261 (p<0,001) 0,210 (p<0,003) -	0,180 (p<0,009) 0,148 (p<0,03) 0,185 (p<0,008) -
Температура: -в момент измерения -накануне исследования -на следующий день				0,148 (p<0,03) 0,145 (p<0,04) 0,159 (p<0,02)			
Относительная влажность: -в момент измерения -накануне исследования -на следующий день	0,149 (p<0,03) 0,140 (p<0,04) 0,196 (p<0,005)			-0,265 (p<0,001) -0,258 (p<0,001) -0,246 (p<0,001)	0,194 (p<0,006) 0,197 (p<0,005) 0,223 (p<0,002)	0,139 (p<0,04) - 0,139 (p<0,03)	
Точка росы:	-		-	-	-	-	-
Облачность верхняя: -в момент измерения -накануне исследования	0,185 (p<0,02) -			- 0,153 (p<0,05)			
Направление ветра:	-		-	-	-	-	-
Скорость ветра:	-		-	-	-	-	-
Индекс геомагнитной активности (Кр-индекс):	-		-	-	-	-	-

Таблица 4.

Корреляционные отношения между показателями гемодинамики (ПАД, АДСР, ДП) и погодными факторами у больных АГ и ИБС, получающих ТТ с мелатонином.

	ПАД утром	**АДср утром**	**ДП утром**	**ПАД вечером**	**АДср вечером**	**ДП вечером**
Атмосферное давление:						
-в момент измерения	0,154 (p<0,03)	0,238 (p<0,001)	-0,262 (p<0,001)	0,147 (p<0,03)	0,268 (p<0,001)	0,254 (p<0,001)
-накануне исследования	0,188 (p<0,007)	0,266 (p<0,003)	-0,248 (p<0,001)	0,163 (p<0,02)	0,289 (p<0,001)	0,258 (p<0,001)
-на следующий день	-	0,154 (p<0,03)	-0,336 (p<0,001)	-	0,184 (p<0,008)	0,203 (p<0,004)
-перепад	-	-	-	0,146 (p<0,03)	-0,141 (p<0,04)	-
Температура: -на следующий день			0,150 (p<0,03)			
Относительная влажность:						
-в момент измерения	0,156 (p<0,02)		-0,242 (p<0,001)	0,164 (p<0,02)	0,214 (p<0,002)	0,197 (p<0,005)
-накануне исследования	0,162 (p<0,02)		-0,234 (p<0,001)	0,172 (p<0,01)	0,210 (p<0,003)	0,206 (p<0,003)
-на следующий день	0,217 (p<0,002)		-0,182 (p<0,009)	0,175 (p<0,01)	0,255 (p<0,001)	0,213 (p<0,003)
Точка росы:	-	-	-	-	-	-
Облачность верхняя:	0,152 (p<0,05)		0,229 (p<0,004)			
-в момент измерения	-		0,207 (p<0,008)			
-накануне исследования						
Направление ветра:			-0,139 (p<0,04)			
-в момент измерения			-0,142 (p<0,04)			
-накануне исследования						
Скорость ветра:	-	-	-	-	-	-
Индекс магнитной активности (Кр-индекс):						
-в момент измерения	0,381 (p<0,001)	-	-	-	-	
-накануне исследования	0,428 (p<0,001)	0,413 (p<0,001)	-	-	0,318 (p<0,001)	
-за 2 дня до измерения	0,312 (p<0,001)	-	-	0,313 (p<0,001)	-	
-на следующий день	0,385 (p<0,001)	0,305 (p<0,001)	-	-	-	
-через 2 дня после измерения	-	-	-	-	0,310 (p<0,001)	
-перепад	-	-	0,350 (p<0,001)	-	-	

Корреляционная связь между утренним уровнем САД и показателями атмосферного давления приходится на момент измерения, на временной сдвиг (опережение) на 1 день и на запаздывание на 1 день. Обнаружены корреляционные связи между параметрами утреннего САД и показателями относительной влажности в момент измерения, накануне исследования. Выявленная связь между утренним САД и верхней облачностью приходится на момент измерения. Зависимость вечернего САД с

показателями атмосферного давления приходится на момент измерения, на временное опережение, на запаздывание на 1 день, а также на перепад параметров атмосферного давления. Зависимость между вечерним уровнем САД и показателями относительной влажности приходится на момент измерения, на опережение и на запаздывание на 1 день.

Параметры утреннего значения ДАД коррелируют с показателями атмосферного давления в момент измерения, накануне исследования и на следующий день. Зависимость вечернего ДАД с показателями атмосферного давления приходится на момент измерения, на временное опережение, на запаздывание на 1 день. Выявленная зависимость вечернего ДАД с показателями относительной влажности приходится на момент измерения и на запаздывание на 1 день.

Утренние значения ЧСС наиболее подвержены корреляционным отношениям с метеофакторами. Выявлена обратная зависимость утреннего ЧСС с показателями атмосферного давления, которая приходится на момент измерения, на опережение и на запаздывание на 1 день. Аналогична связь этого показателя с показателем относительной влажности. Связь утреннего ЧСС с показателем температуры воздуха приходится на те же самые точки, однако зависимость эта - прямая. Корреляционная связь между утренним ЧСС и верхней облачностью выявлена только накануне исследования. Вечерние значения ЧСС менее подвержены влиянию погоды. Выявлены корреляционные связи вечернего ЧСС с показателями атмосферного давления в момент измерения, накануне исследования и на следующий день.

Выявлена прямая связь вечернего ПАД с показателями атмосферного давления, которая приходится на момент измерения. Параметры утреннего ПАД коррелируют с показателями атмосферного давления в момент измерения, накануне исследования, а также с показателями верхней облачности в момент измерения. Прямая зависимость утреннего ПАД с показателями относительной влажности приходится на момент измерения, на опережение и на запаздывание на 1 день. Выявлена прямая связь вечернего ПАД с показателями атмосферного давления, которая приходится на момент измерения, на опережение на 1 день и обратная перепаду метеофактора. Прямая зависимость вечернего ПАД с показателями относительной влажности приходится на момент измерения, на опережение и на запаздывание на 1 день. Выявлено влияние геомагнитной активности на показатели утреннего ПАД в момент измерения, а также на следующий день. Вечернее ПАД демонстрирует связь с показателями атмосферного давления, которая приходится на момент измерения, на опережение на 1 день и обратна перепаду метеофактора. Прямая зависимость вечернего ПАД с показателями относительной влажности приходится на момент измерения, на опережение и на запаздывание на 1 день. Выявлена корреляционная связь между вечерним ПАД и индексом геомагнитной активности за 2 дня до измерения.

Параметры утреннего АД среднего (АДср) коррелируют с показателями атмосферного давления в момент измерения, а также накануне исследования и на следующий день. Влияние магнитной активности на показатели утреннего АДср выявляется накануне исследования и на следующий день. Зависимость вечернего АДср с показателями атмосферного давления приходится на момент измерения, на временной сдвиг (опережение), на запаздывание на 1 день, а также на перепад атмосферного давления. Выявлены корреляционные отношения между показателями вечернего АДср и параметрами относительной влажности в день исследования, накануне исследования и на следующий день. Влияние геомагнитной активности на показатели вечернего АДср приходится на время накануне исследования и через 2 дня после измерения.

Утренние значения двойного произведения (ДП) наиболее подвержены влиянию факторов погоды. Выявлены отрицательные корреляционные связи утреннего ДП с атмосферным давлением в момент измерения, накануне исследования, на следующий день, а также с температурой воздуха на следующий день. Обратная зависимость утреннего ДП с показателями относительной влажности приходится на момент измерения, на опережение и на запаздывание на 1 день, в то время как зависимость этого показателя с показателями верхней облачности приходится только на момент измерения. Зависимость утреннего ДП с показателями верхней облачности приходится на момент измерения и на временной сдвиг (опережение). Отрицательные корреляции между утренним ДП и параметрами направления ветра приходятся на момент измерения, на временной сдвиг и на опережение. Перепад значений индексов геомагнитной активности влияет на показатели утреннего ДП. Зависимость вечернего ДП с показателями атмосферного давления приходится на момент измерения, на временной сдвиг (опережение) и на запаздывание на 1 день. Аналогична и зависимость этого показателя с параметром относительной влажности.

ЗАКЛЮЧЕНИЕ

Приведенные результаты показывают, что традиционное лечение позволило зафиксировать 180 пар значимых корреляционных связей показателей гемодинамики с погодными условиями, в то время как при традиционной терапии с включением мелатонина количество этих пар уменьшается более чем в 2 раза, что указывает на улучшение устойчивости пациентов к факторам внешней среды за счет адаптогенного действия мелатонина.

Таким образом, пациенты, страдающие АГ в сочетании с ИБС и получавшие комплексное лечение с мелаксеном, менее подвержены влиянию погодных факторов. Наибольшее влияние оказывает атмосферное давление и относительная влажность. В меньшей мере выявлено влияние облачности и направление ветра. Не выявлено корреляционных связей показателей гемодинамики с параметрами

точки росы и скорости ветра. Наиболее подвержены погодному влиянию показатели ЧСС и ДП, измеренные в утренние часы. В меньшей степени коррелируют с погодными факторами утренние значения ДАД, АДср и вечерние показатели ЧСС.

Изложенное указывает на повышение устойчивости больных с АГ и ИБС к метеорологическим и гелиомагнитным факторам под влиянием мелатонина и его высокую адаптогенную активность.

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OPTIMIZATION OF THE MEDICAL INFORMATION SYSTEM IN THE WORK OF A HOSPITAL EPIDEMIOLOGIST: RESULTS OF THE STUDY

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ОПТИМИЗАЦИЯ МЕДИЦИНСКОЙ ИНФОРМАЦИОННОЙ СИСТЕМЫ В РАБОТЕ ГОСПИТАЛЬНОГО ЭПИДЕМИОЛОГА: РЕЗУЛЬТАТЫ ИССЛЕДОВАНИЯ

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Abstract

The article presents the results of studying the medical information system in the work of hospital epidemiologists. It is shown that insufficient attention is paid to the issues of satisfaction of epidemiologists in the work of an integrated medical information system. It was revealed that electronic record keeping will help to increase the efficiency of the work of hospital epidemiologists in medical organizations.

Аннотация

В статье представлены результаты изучения медицинской информационной системы в работе госпитальных эпидемиологов. Показано, что вопросам удовлетворенности эпидемиологов в работе комплексной медицинской информационной системы уделяется недостаточное внимание. Выявлено, что электронное ведение документации будет способствовать повышению эффективности работы госпитальных эпидемиологов в медицинских организациях.

Keywords: *medical information system, epidemiologist, optimization*
Ключевые слова: *медицинская информационная система, эпидемиолог, оптимизация*

Считается, что электронное здравоохранение способно положительно влиять и на систему общественного здравоохранения, и на благополучие населения в целом, и на состояние здоровья отдельных граждан [1]. Основным эффектом от внедрения безбумажного здравоохранения является не столько сокращение затрат на бумагу, сколько увеличение мобильности здравоохранения, и совершенствование непрерывности оказания медицинской помощи, которое обеспечивается за счет облегчения интерпретации цифровой информации в противовес заполненным рукописным шрифтом документам [2]. Целью государственной программы «Информационный Казахстан 2020» является вывести на новый уровень качество оказания медицинской помощи населения с помощью внедрения в систему здравоохранения информационных технологий. В рамках государственной программы «Информационный Казахстан 2020» в области электронного здравоохранения до 2020 года одной из основных задач являлась повышение уровня компьютерной грамотности медицинских работников в 2020 году до 100%. С помощью оптимизации медицинской информационной системы можно повысить уровень компьютерной грамотности среди медицинских работников, в частности, эпидемиологов [3]. В 2012г. с привлечением международных экспертов Швейцарского института общественного здравоохранения (Swiss Tropical and Public Health Institute) была проведена оценка эффективности внедрения Е-здравоохранения в РК [2]. С учетом экспертных оценок были проведены мероприятия по улучшению работы систем. С применением системного анализа был подготовлен актуальный SWOT – анализ внедрения ЕИСЗ. К слабой стороне по итогам данного анализа отнесли отсутствие удобства использования (принцип user-friendly), ввиду медленной работы, многократного ввода одной информации в нескольких системах; что увеличивает время работы врача [4]. Работа системы здравоохранения и в будущем во многом будет зависеть от надежного и слаженного функционирования информационных систем. В то же время новые тенденции в здравоохранении и новые подходы к оказанию медицинской помощи и к ее организации потребуют дополнительных функциональных возможностей медицинской информационной системы, которые должны разрабатываться совместно врачами и специалистами по информационным технологиям [5]. Параллельное ведение бумажной медицинской документации удваивает работу с документацией, как в бумажном, так и в электронном форматах, в ущерб времени, проводимому с пациентом [4]. Учитывая в настоящее время эпидемиологическую ситуацию в Республике Казахстан, необходимо предпринимать решительные шаги в оптимизации медицинской информационной системы в работе эпидемиологов. Доступ к медицинской информационной системе для эпидемиологов позволит улучшить уровень оказания медицинской помощи, проводить качественные противоэпидемические мероприятия. Усовершенствование данной системы на уровне страны является сложным и длительным процессом, который требует привлечения не только технических специалистов, но и медицинского персонала [6]. Ведь именно специалисты лечебно-профилактических учреждений понимают нужность функционирования системы и могут подробно описать процессы, которые необходимо оптимизировать. **Целью исследования** явилось оптимизация медицинской информационной системы в соответствии с должностными обязанностями госпитального эпидемиолога.

Материалы и методы. Для того чтобы оптимизировать медицинскую информационную систему в работе госпитальных эпидемиологов нами было изучена комплексная медицинская информационная система, используемая в лечебно-профилактических учреждениях. Вместе с тем, было проведено анкетирование 120 эпидемиологов, работающих в медицинской организации с помощью специально разработанной анкеты. Анкетирование направлено на оценку удовлетворённости госпитальных эпидемиологов работой в комплексной медицинской информационной системе (-далее КМИС). Исследование проводилось в виде одномоментного количественного исследования и структурированного интервью (самозаполнение анкет). Респонденту предлагалось выбрать один из нескольких предложенных вариантов ответов. Эпидемиологам объяснялась цель проводимого исследования и предлагалось принять участие в опросе анонимно и добровольно.

Результаты и их обсуждения. По итогам анкетирования выявлено, что большую часть респондентов составили эпидемиологи со стажем работы от 1 года до 5 лет - 52,5%, 20,9% медицинских работников данного профиля со стажем до 1 года, 15,8% от 5 до 10 лет и 10,8% от 10 лет и выше.

На вопрос, как бы оценили свое участие в обучении по работе с КМИС 62,5% респондентов считают, что обучения для эпидемиологов не проводилось, 21,7% эпидемиологов проходили обучение, 10,7% не обучались и 6% от выборки - затруднялись ответить на данный вопрос (рисунок 1).

Рисунок 1 - Оцените Ваше участие в обучении медицинского персонала по работе с КМИС

При оценке уровня доступности информации, предоставляемой КМИС, по профилю были получены следующие ответы:

1) по уровню доступности к персональным данным пациента (хороший – 43%, удовлетворительный – 61%, неудовлетворительный – 10%, затрудняюсь ответить – 6%);

2) по уровню доступности к прививочному статусу пациента (хороший – 26%, удовлетворительный – 63%, неудовлетворительный – 24%, затрудняюсь ответить – 7%);

3) по уровню доступности к информации о контакте с больным Covid-19, туберкулезом, вирусным гепатитом, корью и т.д. (хороший – 26%, удовлетворительный 53%, неудовлетворительный – 31%, затрудняюсь ответить – 10%);

4) по уровню доступности к информации о сведениях о больном Covid-19 (хороший – 20%, удовлетворительный – 51%, неудовлетворительный – 37%, затрудняюсь ответить – 12%);

5) по уровню доступности к информации о сведениях о проведении противоэпидемических мероприятий, отраженных в историях болезни (хороший – 15%, удовлетворительный – 44%, неудовлетворительный – 49%, затрудняюсь ответить 12%).

На вопрос «Как бы в целом оценили КМИС по ведению документации по Вашему профилю?» были получены следующие ответы респондентов:

1) в отношении журнала регистрации инфекционных и паразитарных заболеваний ф.060/у - 12,5% от выборки поставили оценку «отлично», «хорошо» отметили 11,7% опрошенных, наибольшая часть 45,8% от выборки ответили, как «удовлетворительно» и 30% поставили оценку «неудовлетворительно»;

2) по ведению журнала учета профилактических прививок ф.064/у в КМИС оценку «отлично» поставило 10,8% респондентов, как «хорошо» 17,5%, удовлетворительную оценку указала наибольшее количество опрошенных – 45,9% и 25,8% от всей выборки отметили ведение данного журнала как «неудовлетворительно»;

3) оценку «отлично» поставило 15,8% по ведению журнала учета температуры пациентов в КМИС, «хорошо» - 25,8%, «удовлетворительно» оценила наибольшая часть опрошенных 41,7% и как «неудовлетворительно» 16,7% опрошенных, что от выборки;

4) по форме регистрации экстренных извещений ф.090/у, «отлично» – 11,7% опрошенных от выборки, «хорошо» 12,5%, «удовлетворительно» – 45% и «неудовлетворительно» – 30,8%.

На рисунке 2 показаны ответы респондентов на вопрос «Оцените Ваше участие в работе с КМИС при регистрации инфекционного заболевания» респонденты ответили, что 29,7% не участвовали в работе, наибольшая часть от выборки 47,4% участвовали в полном объеме, 9,3% респондентов указали, что не умеют работать в КМИС и 13,6% - затрудняются ответить на вопрос.

Рисунок 2 - Оцените Ваше участие в работе с КМИС при регистрации инфекционного заболевания

«Изменился ли бы Ваш план работы на день, если бы КМИС стал более доступным для госпитальных эпидемиологов?» на данный вопрос наибольшая часть респондентов 70,6% ответили «Да. Работать стало бы легче.», 14,3% от выборки считают, что все осталось бы по-прежнему, затруднились в ответе 8,4% и 6,7% ответили, что работать стало бы сложнее.

Ответы респондентов на вопрос «Если бы в КМИС, при поступлении пациента в стационар, обозначали маркером с подозрением на инфекционное заболевание, оптимизировалась бы работа в схеме оповещения?» 70,9% респондентов ответили, что мероприятия по схеме оповещения были бы сработаны быстрее, 13,3% от выборки в ответе затрудняются и 15,8% ответили, что все осталось бы по-прежнему.

На рисунке 3 отражены ответы респондентов на вопрос «Пользуетесь ли Вы КМИС при регистрации больного Covid-19 с дальнейшим проведением противоэпидемических мероприятий?». По результатам анкетирования установлено, что 29,1% пользовались КМИС при регистрации больного Covid-19 с дальнейшим проведением противоэпидемических мероприятий в полном объеме, 26,7% - не пользовались, 33,3% - пользовались частично и 10,9% затруднялись в ответе.

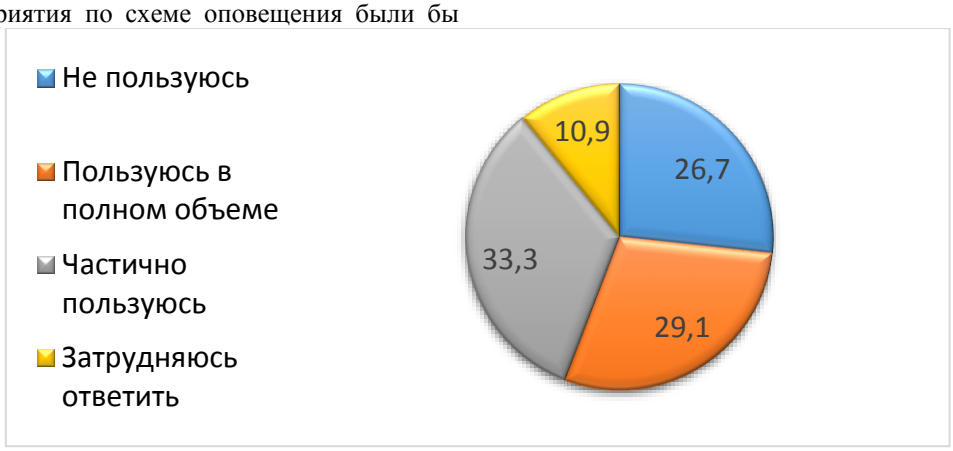

Рисунок 3 - Пользуетесь ли Вы КМИС при регистрации больного Covid-19 с дальнейшим проведением противоэпидемических мероприятий? (%)

На вопрос «Пользуетесь ли Вы КМИС при проверке прохождения медицинского осмотра медицинскими работниками?» 55,4% респондентов ответили нет не пользуемся, но было бы удобнее проверять в КМИС, если бы была отдельная вкладка для медицинских работников, 28,1% от выборки проверяют только по журналам в бумажном виде, 14,8% - пользуются, но это занимает много времени и затруднились в ответе 1,7% медицинских работника (рисунок 4).

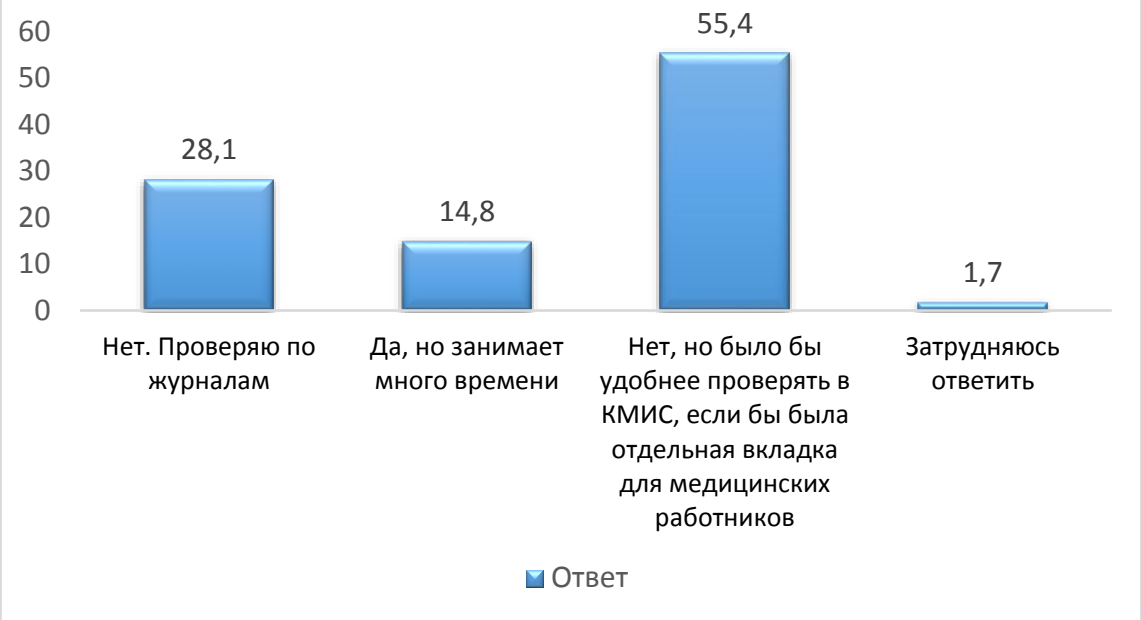

Рисунок 4 - Пользуетесь ли Вы КМИС при проверке прохождения медицинского осмотра медицинскими работниками (%)

На рисунке 5 показаны ответы респондентов на вопрос «Удобно ли было бы Вам работать в КМИС, если был бы внедрен отдельный модуль для эпидемиолога?» наибольшая часть респондентов 83,4% ответили положительно «Да», 11,6% от всей выборки - затрудняются ответить и 5% - ответили «Нет».

Рисунок 5 - Удобно ли было бы работать в КМИС, если был бы внедрен отдельный модуль для эпидемиолога (%)

Заключение. Таким образом, результаты исследования показали, что в информационной системе здравоохранения необходимо оптимизировать медицинскую информационную систему для работы эпидемиологов. Эпидемиологам будет удобнее работать в комплексной медицинской информационной системе, если будет внедрен модуль «Эпидемиолог», где специалист сможет централизованно вести учетно-отчетную документацию. Электронное ведение документации будет способствовать повышению эффективности работы госпитальных эпидемиологов в медицинских организациях.

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APPLICATION OF PREPARATIONS OF ANGIOPROTECTIVE AND PROFIBRINOLYTIC ACTION, AS WELL AS MODERN METHODS OF HEMOSTASIS CONTROL IN PATIENTS WITH NEW CORONAVIRUS INFECTION (COVID-19) IN THE ACTIVE STAGE OF HEMOSTASIS

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Abstract

Coronavirus Disease 2019 (COVID-19) is associated with a hypercoagulable state associated with acute inflammatory changes and laboratory findings, which is different from acute disseminated intravascular coagulation syndrome (DIC), except in patients with very severe disease. Significant changes in the coagulogram occur - fibrinogen and D-dimer increase, usually with a slight increase in prothrombin time (PT) and activated partial thromboplastin time (APTT) and moderate thrombocytosis or thrombocytopenia. The pathogenesis of these abnormalities is not fully understood, and can be multifactorial, such as an acute inflammatory reaction, as a response to the underlying disease.

The risk of venous thromboembolism (VTE) is markedly increased, especially in intensive care unit (ICU) patients, with a 25 to 43 percent prevalence among ICU patients in series, often despite prophylactic doses of anticoagulants. The risk of developing pulmonary thrombosis also increases. The risk of arterial thrombotic events such as stroke, myocardial infarction and limb ischemia is also increased.

CONFLICT OF INTEREST

The authors declare no possible conflicts of interest.

Keywords: novel coronavirus infection COVID-19, deep vein thrombosis of the lower extremities, thrombodynamics, coagulation system, D-dimer, fibrinogen, hypercoagulability, sulodexide, rivaroxaban.

BACKGROUND:

At the end of 2019, a new coronavirus was identified and quickly reached pandemic proportions. The disease caused by the virus (Severe Acute Respiratory Syndrome, Coronavirus 2 [SARS-CoV-2]) has been designated by the World Health Organization as the 2019 Coronavirus Disease (COVID-19).

People with COVID-19 can have a range of complex and varied bleeding disorders (mainly hypercoagulable states), which raises questions about appropriate assessments and interventions to prevent or treat thrombosis.

Pathogenesis:

Endothelial damage. There is evidence of direct invasion of endothelial cells by coronavirus 2 (SARS-CoV-2) severe acute respiratory syndrome virus, which can lead to cell damage. Some experts argue that endothelial injury, microvascular inflammation, endothelial exocytosis and / or endotheliitis play a central role in the pathogenesis of acute respiratory distress syndrome and organ failure in patients with severe COVID-19 [1-3].

Other observations suggest a role for extracellular neutrophil traps (NET), a form of decondensed chromatin displaced by dead or dying neutrophils, in the prothrombotic state of COVID-19 [4,5].

Other sources of endothelial damage include intravascular catheters and acute systemic inflammatory response mediators such as cytokines (eg interleukin [IL] -6) and other acute phase reagents [6]. The contribution of complement-mediated endothelial damage has been suggested, and in vitro studies have shown that the SARS-CoV-2 spike protein can activate an alternative complement pathway [7,8].

Congestion - Immobilization can cause blood flow stagnation in all hospitalized and critically ill patients, regardless of whether they have COVID-19.

Hypercoagulable state. A number of changes in circulating prothrombotic factors have been reported in patients with severe COVID-19 [9-11]:

- Increased factor VIII
- Increased fibrinogen
- Circulating prothrombotic microparticles
- Extracellular neutrophil traps (NET)
- Increased viscosity

Hyperviscosity has been demonstrated in 15 critically ill patients in the intensive care unit (ICU) [12]. All 15 had an increased plasma viscosity as assessed by capillary viscometry (range 1.9 to 4.2 cP; normal range 1.4 to 1.8 cP). The increased viscosity is believed to contribute to the hypercoagulable state.

This is often associated with monoclonal gammopathies, especially Waldenstrom macroglobulinemia, but it can also be caused by polyclonal increases in gamma globulins and / or large increases in other proteins such as fibrinogen.

Very elevated D-dimer levels were observed that correlate with disease severity; D-dimer is a degradation product of cross-linked fibrin, which indicates an increase in the formation of thrombin and

dissolution of fibrin by plasmin [13]. The potential role of platelet activation in thrombosis has also been discussed, although data are limited [14,15].

Coagulation abnormality - The predominant coagulation abnormality in COVID-19 patients is indicative of hypercoagulability and is consistent with uncontrolled clinical findings with an increased risk of venous thromboembolism.

Some experts have called this condition thrombus inflammation or COVID-19 associated coagulopathy (CAC) [16,17]. It appears to differ from disseminated intravascular coagulation (DIC), although DIC has been reported in patients with severe coronavirus infection.

Laboratory findings were characterized in 24 selected patients with severe COVID-19 pneumonia (intubated) who were examined along with a standard coagulation test and other tests, including von Willebrand factor (VWF) and thromboelastography (TEG) [9]:

Local tests for assessing hemostasis:

• Prothrombin time (PT) and APTT are normal or slightly increased

• The number of platelets is normal or increased (average 348 * 10 / 9L)

• Increased fibrinogen (average 6.80 g / l; range 2.34 to 13.44)

• D-dimer increased (average 4877 ng / ml; range 1197 to 16 954)

Other analyzes

• Increased factor VIII activity (average 297 units / dl)

• The VWF antigen level is significantly elevated (average 529; range 210 to 863), consistent with endothelial damage or disruption.

• Minor changes in natural anticoagulants

• Small reduction in antithrombin and free protein S

• Small increase in protein C

Data from integral tests for assessing hemostasis (thromboelastography) - TEG:

• Reaction time (R) is shortened, which corresponds to an increase in early thrombin release in 50 percent of patients.

• Clotting time (K) is shortened, corresponding to an 83 percent increase in fibrin formation.

• Maximum Amplitude (MA) increased, corresponding to greater bunch strength, by 83 percent.

• Lysis of the clot after 30 minutes (LY30) is reduced, which corresponds to a decrease in fibrinolysis by 100 percent

Other studies have reported similar results consistent with the state of hypercoagulability, including very high D-dimer levels, VWF antigen and activity, and factor VIII activity [10,18]. One study, which performed TEG in 44 patients in the intensive care unit, found complete absence of clot lysis (LY30 0 percent) in 57 percent, which is called "fibrinolysis off" and is associated with a high incidence of renal failure and thromboembolic events [19].

Another study found that patients with COVID-19 had higher platelet counts than patients with other coronavirus infections [20].

A series from Ireland, which included 50 patients in a conventional medical unit, reported results similar to those in the intensive care unit, including high D-dimer and fibrinogen levels, normal platelet counts and clotting times [21].

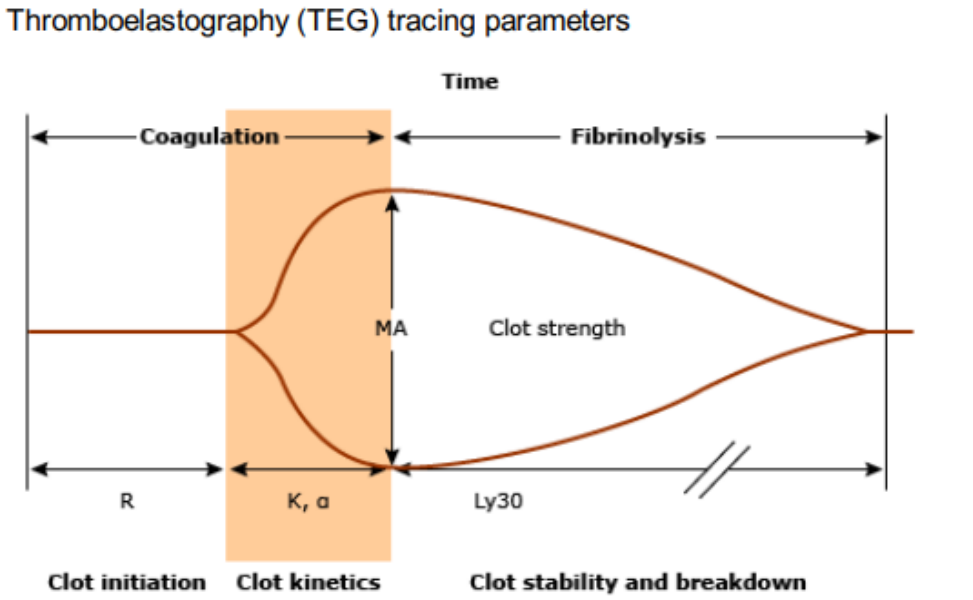
An early series of cases, including a series of 183 consecutive patients from Wuhan, China, showed that thrombocytopenia and lengthening of PT and APTT were more pronounced [22-25]. It is unclear why these results were slightly different from more recent data on less severe PT and prolonged APTT. One possible explanation is that these patients were worse, possibly because the disease was not recognized as quickly during the pandemic earlier, leading to delays in patient referral and / or treatment. Cases of immune thrombocytopenia (ITP) associated with COVID-19 have been reported [26-29].

Another explanation for isolated prolonged aPTT is the presence of a lupus anticoagulant (LA). Two studies have shown a high level of PA in patients with prolonged APTT (50 of 57 people tested [88 percent] and 31 of 34 people tested [91 percent]) [18,30].

Another study, which re-tested 10 LA-positive people with COVID-19 after a few weeks, found that 9 out of 10 subsequently became negative [31]. The phenomenon of transient antiphospholipid antibodies (aPL) -positiveness is often found in persons with acute viral infections and is not an antiphospholipid syndrome. However, LA positiveness may correlate with thrombosis in people with COVID-19 [32]. The presence of LA can lead to artifact lengthening of APTT, but does not reflect an increased risk of bleeding; Patients with LP should receive anticoagulants when indicated.

Some of the markers of coagulation disorder (eg D-dimer) seem to correlate with disease severity.

The principles of TEG and the interpretation of TEG curves are shown in the figure.



"R" is the reaction time (the time it takes the coagulation cascade to generate thrombin and fibrin). "K" is the clot firmness. "α" (alpha) is the angle (describes the kinetics of clot formation). MA is the maximum amplitude (describes the maximum clot strength). Ly30 is the percent clot lysis 30 minutes after the MA is reached. Refer to UpToDate topics on platelet function testing and trauma management for details of the use and interpretation of thromboelastography.

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Difference from DIC - hypercoagulable syndrome - a condition associated with COVID-19 has been referred to by some as a disseminated intravascular coagulation (DIC) -like condition, especially because many victims are acutely ill and meets the criteria for probable DIC in a scoring system published by the International Society on thrombosis and hemostasis (ISTH) in 2009 [33].

However, the main clinical sign of COVID-19 is thrombosis, while the main sign of acute decompensated disseminated intravascular coagulation is bleeding.

Likewise, COVID-19 has some laboratory findings similar to DIC, including a marked increase in D-dimer and, in some cases, mild thrombocytopenia. However, other parameters of coagulation in COVID-19 differ from DIC. In COVID-19, typical results include high fibrinogen levels and high factor VIII activity, suggesting that significant consumption of clotting factors is not occurring [9].

In contrast, acute decompensated DIC is associated with low fibrinogen levels due to consumption of clotting factors. In one of the largest series in which thromboembolic events were reported, none of the patients developed overt disseminated intravascular coagulation [34].

As a rule, bleeding predominates in acute decompensated disseminated intravascular coagulation syndrome, and thrombosis predominates in chronic compensated disseminated intravascular coagulation syndrome, although there is significant overlap. Thus, the hypercoagulable state in COVID-19 patients is more like compensated disseminated intravascular coagulation syndrome than acute disseminated intravascular coagulation syndrome, which is consistent with the conclusion that platelet count and APTT are generally normal.

This ISTH scoring system is laboratory-based and is intended only for use in patients with an underlying disease known to be associated with DIC [33]. COVID-19 will be qualified based on serious infection. Points are assigned for thrombocytopenia (1 point for platelet counts 50,000 to 100,000 / μL; 2 points for <50,000 / μL), long PT (1 point for 3 to 6 seconds of extension; 2 points for more than 6 seconds), low fibrinogen (1 point for <100 mg / dL) and an increase in D-dimer (2 points for a moderate increase; 3 points for a "strong" increase). A score of 5 or more suggests the likelihood of DIC. Despite this, the diagnosis of DIC is made clinically; there is no gold standard, and there is no single test or combination of tests that is pathognomonic. Compared to expert opinion, the ISTH scoring system has a sensitivity of 91 percent and a specificity of 97 percent [33].

Whether the differences from disseminated intravascular coagulation or similarities are emphasized, many of the basic principles of treatment for disseminated intravascular coagulation (DIC) apply, including

the importance of treating the underlying condition, the importance of basing interventions on clinical presentation rather than laboratory testing, and the need to provide anticoagulant therapy for thrombosis and appropriate hemostatic therapy for bleeding.

Coaguological disorders observed in patients with COVID-19:

Venous thromboembolism (VTE), including extensive deep vein thrombosis (DVT) and pulmonary embolism (PE), is very common in patients with acute COVID-19 disease and occurs in one third of patients in the intensive care unit (ICU), even with prophylactic anticoagulation ...

In a large study involving more than 3,000 people admitted to the hospital, most of whom received prophylactic anticoagulants, risk factors for VTE on multivariate analysis were old age, male gender, Hispanic ethnicity, coronary heart disease, previous myocardial infarction and above ... D-dimer (> 500 ng / ml) during hospitalization [35]. VTE was associated with an increased mortality rate (adjusted hazard ratio [HR] 1.37; 95% CI 1.02–1.86).

As noted in the sections below, there has been a general trend over time from a higher risk of VTE in hospitalized patients in the early stages of a pandemic to a lower risk in later stages of a pandemic, although the risk of VTE in hospitalized patients remains a major concern. The risk of post-discharge VTE appears to be similar to or only marginally higher than the risk of acutely ill hospitalized patients without COVID-19 after discharge.

Several autopsy studies have highlighted the effects of hypercoagulability and associated inflammation in patients dying from COVID-19:

Pathological examination of 21 people with COVID-19 showed severe PE in four, with microthrombi in the alveolar capillaries in 5 of 11 (45 percent) who had available histology [36]. Three had evidence of thrombotic microangiopathy with fibrin clots in the glomerular capillaries. The median age was 76 years, and most of them had a high body mass index (BMI; mean 31 kg / m 2; normal 18.5 to <25). Information on anticoagulant use prior to death was available for 11, and all 11 received some form of anticoagulant. Cardiovascular diseases, hypertension and diabetes mellitus were common.

Postmortem examination of 12 consecutive COVID-19 individuals (8 men; 10 hospitalized) found DVT in 7 of 12 (58 percent) [37]. All DVT cases had bilateral leg involvement, and none were suspected to be dead. Of the 12 people with lung histology available, 5 (42 percent) had evidence of thrombosis. PE has caused four deaths. Those who had the D-dimer test had extremely high values (two> 20,000 ng / ml and one> 100,000 ng / ml; normal value <500 ng / ml [<500 μg / L]) ... Anticoagulant use before death was reported in only 4 out of 12. The mean BMI was 28.7 kg / m 2; only three patients had a normal BMI and had cancer, ulcerative colitis, and / or chronic kidney disease.

An autopsy comparing the pulmonary pathology of seven people who died from COVID-19 found severe endothelial damage (endotheliitis), widespread thrombosis with microangiopathy and microthrombi of the alveolar capillaries, and increased angiogenesis, all of which were significantly more pronounced in the lungs of patients who died from COVID-19, compared with lungs of the control group who died from influenza or other causes [38].

Stroke . The Unified Health System identified five cases of acute ischemic stroke associated with COVID-19 over a two-week period with symptoms suggestive of large vessel occlusion; all patients were under 50 years of age [39]. At other times before the pandemic, individuals under 50 years of age had approximately 0.7 large vessel strokes over a two-week interval. In one of the ICU patient groups described above, ischemic stroke occurred in 3 out of 184 patients (cumulative incidence 3.7%) [34]. In another study from the series described above, cerebral ischemia was observed in 3 out of 150 [18]. In a series of 314 inpatients who did not receive ICU, six (2%) had ischemic strokes; another three in the intensive care unit suffered ischemic stroke.

Lower limb ischemia - A report described 20 patients with COVID-19 who developed acute limb ischemia in one institution over a period of three months [40]. This represents a significant increase in limb ischemia over the previous year (16 percent compared to 2 percent at the beginning of 2019). The majority were men (18 out of 20), with an average age of 75. Surgery for surgical revascularization was performed in 17 patients, of whom 12 (71 percent) were successful, which is below the expected success rate. Individuals who received postoperative heparin did not require re-intervention, although the benefits of postoperative heparin did not reach statistical significance.

Another report described four patients with acute limb ischemia due to thrombosis, two of whom were young and had no underlying medical conditions (a 53-year-old man who developed aortoiliac thrombosis and a 37-year-old man who developed thrombosis brachial artery). [41]. Both received a prophylactic dose of low molecular weight heparin during the development of thrombosis, and both had very high D-dimer levels (> 9000 ng / ml).

Microvascular Thrombosis - At autopsy, some people who died from COVID-19 have demonstrated microvascular thrombosis in the lungs [7,17,36,38].

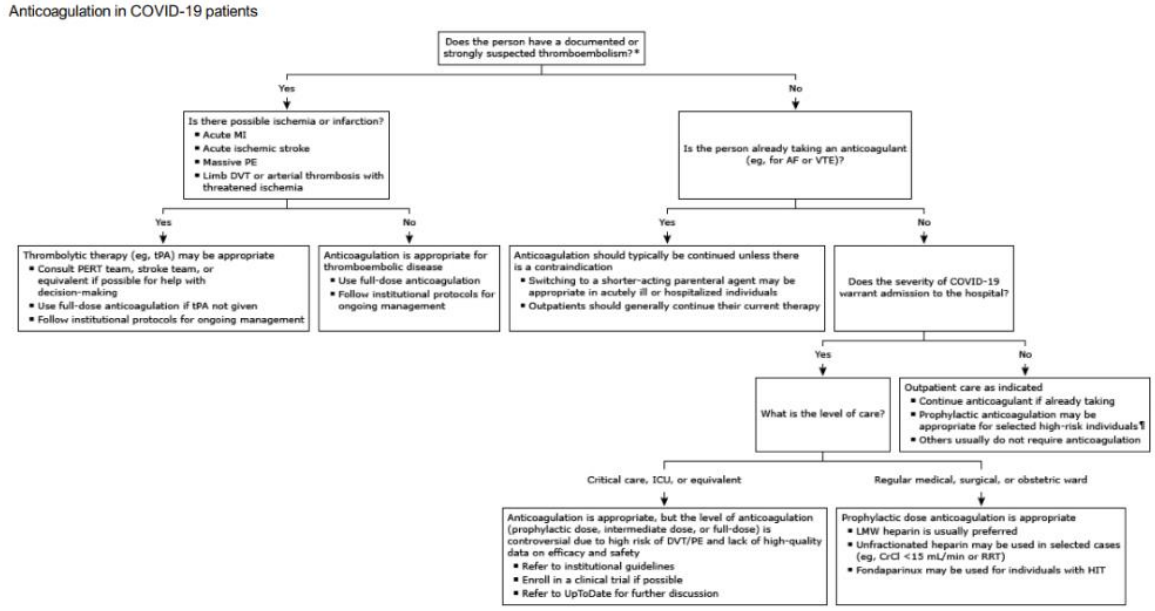
Other reports describe pulmonary perfusion disorders that have been attributed to thromboembolic disease [42].

The mechanism is unclear and may include hypercoagulability, direct endothelial damage, complement activation, or other processes.

Bleeding - Bleeding is less common in patients with COVID-19 than blood clotting, but it can occur, especially with anticoagulation.

Endothelial damage is a well-known component of hypercoagulability.

Venous thromboembolism (VTE) prophylaxis is advisable in all hospitalized medical, surgical, and obstetric patients with COVID-19 unless there are contraindications to anticoagulation (eg, active bleeding or severe bleeding in the previous 24 to 48 hours).



COVID-19 is a hypercoagulable state, and the risk of thromboembolic disease is increased in critically ill (and sometimes well-appearing) individuals. Thromboembolism is typically venous but in some cases may be arterial. Bleeding is much less common but can occur, including intracerebral bleeding, highlighting the importance of documenting ischemia or thrombosis when feasible.

COVID-19: coronavirus disease 2019; MI: myocardial infarction; PE: pulmonary embolism; DVT: deep vein thrombosis; AF: atrial fibrillation; VTE: venous thromboembolism; tPA: tissue plasminogen activator; PERT: pulmonary embolism response team; ICU: intensive care unit; LMW: low molecular weight; CrCl: creatinine clearance; RRT: renal replacement therapy; HIT: heparin-induced thrombocytopenia.

* Appropriate testing to document suspected thromboembolism is advised if feasible. Assistance from a specialist (pulmonary, critical care, hematology) may be required. Refer to UpToDate for details of testing.

¶ High-risk features include prior VTE, recent surgery or trauma, immobilization, or obesity.

Quick reference for evaluation and management of COVID-19-associated hypercoagulability Evaluations and monitoring

Inpatients	Daily PT, aPTT, fibrinogen, D-dimer Diagnostic imaging studies if feasible for clinically suspected DVT or PE; consult PERT team Alternative evaluations if standard imaging studies are not feasible
Outpatients Routine coagulation testing is not required Management	Use for prognostic information and level of care Do not intervene solely based on coagulation abnormalities
VTE prophylaxis	Prophylactic dose anticoagulation for all inpatients Intermediate or therapeutic dose anticoagulation for selected critically ill individuals (eg, in the ICU) Possible continued thromboprophylaxis following discharge Possible thromboprophylaxis in selected outpatients
VTE treatment	Therapeutic (full-dose) anticoagulation for documented or presumptive diagnosis of VTE Initiate in hospital per standard protocols Consider extended thromboprophylaxis following discharge Reserve fibrinolytic agents (eg, tPA) for limb-threatening DVT, massive PE, acute stroke, or acute MI; consult PERT or stroke team
Clotting in vascular catheters or extracorporeal circuits*	Therapeutic (full-dose) anticoagulation Standard protocols for continuous renal replacement therapy or ECMO
Bleeding	Similar to individuals without COVID-19 Transfusions for anemia or thrombocytopenia Anticoagulant reversal and/or discontinuation for anticoagulant-associated bleeding Specific treatments (eg, factor replacement) for underlying bleeding disorders Avoid antifibrinolytic agents in individuals with acute decompensated DIC

*Refer to UpToDate for discussions of COVID-19 management and related topics. Resources are also available from the International Society on Thrombosis and Haemostasis (https://onlinelibrary.wiley.com/doi/10.1111/jth.14853), the American Society of Hematology (https://www.hematology.org/covid-19/covid-19-and-coagulopathy), and the American College of Cardiology (http://surl.li/jggv). COVID-19: coronavirus disease 2019; PT: prothrombin time; aPTT: activated partial thromboplastin time; DVT: deep vein thrombosis; PE: pulmonary embolism; PERT: pulmonary embolism response team; VTE: venous thromboembolism; ICU: intensive care unit; tPA: tissue plasminogen activator; MI: myocardial infarction; ECMO: extracorporeal membrane oxygenation; DIC: disseminated intravascular coagulation. * Includes continuous renal replacement therapy (CRRT; eg, hemodialysis), ECMO, or other extracorporeal circuits. ¶ Acute decompensated DIC is associated with clinical bleeding (and/or thrombosis) and laboratory findings including prolonged PT and aPTT, thrombocytopenia, and hypofibrinogenemia. Antifibrinolytic agents (tranexamic acid and epsilon aminocaproic acid) are avoided because they may tip the balance towards thrombosis. Refer to UpToDate for details*

Outpatient Thromboprophylaxis - Individuals with documented VTE require a minimum of three months of anticoagulation.

Post-discharge prophylaxis options include those used in clinical trials, such as rivaroxaban 10 mg daily for 31–39 days [43].

Studies have noted a predominance of men with a high prevalence of obesity and other chronic comorbidities, especially cardiovascular disease, hypertension and diabetes. Subsequent studies have shown similar results [39].

The administration of sulodexide after discontinuation of anticoagulant treatment reduces the risk of relapse without an apparent increase in the risk of bleeding. [44].

MATERIALS AND METHODS:

The study involved 200 patients with moderate, severe (who received inpatient treatment), and a mild form of new coronavirus infection (COVID-19) with changes in the parameters of the coagulation system, with high / intermediate risks of VTE.

The patients were randomly divided into two groups, 100 people each. One group, after discharge from the hospital, and after discontinuation of anticoagulants, took sulodexide in therapeutic dosages, the other group did not.

Before the appointment of sulodexide, both groups of patients underwent the same examination aimed at identifying changes in the hemostatic system.

The survey included local tests for assessing the coagulation system:

Complete blood count (CBC) including morphological platelet count

- Coagulation studies (prothrombin time [PT] and activated partial thromboplastin time [aPTT])
- Fibrinogen
- The activity of natural anticoagulants (protein C and S, antithrombin III).
- D-dimer
- Integral test for assessing hemostasis - thrombodynamics (the indicators were assessed:

V, [μm / min]. Clot growth rate.

Tlag, [min]. Lag time is the delay in the onset of clot formation after plasma contact with the activator insert.

Tsp, [min]. Time of appearance of spontaneous bunches in the plasma volume.

In both groups, the same values of change in indicators were noted, as noted above:

- High D-dimer
- High fibrinogen
- Normal or slightly prolonged PT and APTT
- Mild thrombocytopenia or thrombocytosis, or normal platelet count
- V, [μm / min]. Increased rate of clot growth.
- Tlag, [min]. A sharp decrease in the delay time of the onset of clot formation after plasma contact with the activator insert.
- Tsp, [min]. The appearance of spontaneous bunches in the plasma volume was noted.

Patients from the control group were prescribed sulodexide in a dosage of 1 capsule (250 mg) 2 times a day between meals. The duration of therapy was 21 days.

Re-examination in both groups was carried out at least 2 times a week or less often, depending on the severity of the patient's illness, the initial test result and the trend of values.

Patients from the control group showed a normalization of the indices of local tests for assessing hemostasis, as well as the normalization of the values of the rate indices of clot growth according to the data of the integral test (thrombodyingamic) by the end of the 2nd week of the study (on average, 13th - 17th days of sulodexide administration), Comparison, the normalization of these indicators was noted only starting from the 35th day of the study (on average, 35th - 43rd days), i.e. the risks of developing severe thrombotic complications persisted for more than six weeks!

CONCLUSIONS

Despite the aggravated prothrombotic history, activation of blood coagulation during the course of a new coronavirus infection (COVID-19) and a high risk of fatal thrombotic complications, the use of modern, complex, prolonged anticoagulant therapy and the use of monitoring its effectiveness make it possible to successfully prevent thrombotic disorders in patients with COVID-19 both during active illness and in convalescents.

DISCUSSION

As a result of the use of highly effective modern methods for assessing the coagulation potential of peripheral blood serum and monitoring the activity of anticoagulant drugs, it is possible to successfully prevent the development of thrombotic complications in patients with COVID-19. This method allows with ease and maximum minimization of risks (hemorrhagic and thrombotic) to carry out accompanying anticoagulant therapy in this group of patients. The use of drugs with an angioprotective and profibrinolytic effect reduces the time required for the restoration of normal coagulation potential and minimizes the risks of developing severe thrombotic complications. Of course, further research is required, but subsequently, with an increase in the number of real clinical observations, all this will contribute to the development of recommendations for the management of patients with a new coronavirus infection (COVID-19)

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PHYSICAL SCIENCES

INVISIBLE UNIVERSES CAN BE SEEN IN ANOMALOUS ZONES[1]

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Abstract

The authors of the existing version of the special theory of relativity had to use the principle of light speed non-exceedance to explain relativistic formulas obtained therein within the space of real numbers. The principle implied existence of only our visible universe and absence of physical content in imaginary numbers.

However, since the principle is just a postulate, i.e. an unproven assumption, it has always carried little credibility. The paper refutes the principle by the experimentally proven principle of physical reality of imaginary numbers. As follows from the principle of physical reality of imaginary numbers, relativistic formulas of the existing version of the STR are wrong and incorrectly explained, and conclusions drawn from them are misguided. In other words, this version is incorrect[2] and, thus, the STR was not actually created in 20th century. Moreover, it could not be created in the 20th century, as its creation required experimental data obtained in the 21st century.

The paper provides an alternative version of the STR containing relativistic formulas corrected given experimental data obtained in the 21st century. These formulas imply that instead of the Monoverse, whose existence is supposed in the existing version of the STR, there is a Multiverse, whose universes are mutually invisible (and the invisibility is explainable) and therefore it has been referred to as hidden.

The paper explains that existence of invisible universes of the hidden Multiverse gives rise to the phenomenon of dark matter and dark energy that is actually a sort of optical effect (however, not electromagnetic, but gravitational), a shadow, rather than some physical substance[3]. It also explains that existence of other invisible universes outside the hidden Multiverse gives rise to the phenomenon of dark space.

Invisible universes are claimed to really exist, which can be experimentally proved by astronomical observations in anomalous zones, where universes not visible outside anomalous zones become partially visible. Therefore, constellations observed in the starry sky inside the anomalous zones are slightly different from those observed in our visible universe.

The alternative version of the special theory of relativity can also successfully solve other issues of astrophysics. In particular, it can explain where antimatter is located and why it does not annihilate with matter, as well as where tachyons are located and why they don't violate the principle of causality, etc.

Keywords: *imaginary numbers; special theory of relativity; dark matter; dark energy; dark space; Multiverse; Hyperverse; invisible universes.*

1. Introduction

The special theory of relativity (STR) [1-3] is considered to be the greatest achievement of physics of 20th century. The theory asserts that according to the principle of light speed non-exceedance our visible universe is the one and only. However, such assertion has always been reasonably mistrusted[4], since it follows from the above-mentioned postulated principle that is actually an unproven assumption. Moreover, the trigger for appearance of this principle in the STR was quite obvious and had nothing to do with any serious theoretical research. The authors of the STR [4-7] needed the principle only because they did not have correct explanation for relativistic formulas (the main result of their theory) taking imaginary values at hyper-light speeds within the framework of real number physics. And in order to avoid non-recognition of their theory, they would like to divert attention from this circumstance, one way or another.

It seemed as if the use of the principle of light speed non-exceedance allowed them to do this. Nevertheless, the authors of the existing version of the STR were so discouraged by this circumstance that further STR development ceased for almost a century[5]. And

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[1] *This is an extended version of the article "**Antonov A.A.** (2020) Universes being invisible on Earth outside the portals are visible in portals. Natural Science. 569-587".*

[2] *No undertaking may be considered complete, unless it is properly done. No one would drink coffee, if salt is put thereto instead of sugar.*

[3] *And, therefore, it cannot be detected at the Large Hadron Collider.*

[4] *The STR was criticized by Oliver Heaviside, Nikola Tesla, Nobel Prize winner Albert Abraham Michelson, Nobel Prize winner Friedrich Wilhelm Ostwald, Nobel Prize winner Joseph John Thomson, Nobel Prize winner Svante August Arrhenius, Nobel Prize winner Philipp Eduard Anton von Le-nard, Nobel Prize winner Alvar Gullstrand, Nobel Prize winner Wilhelm Carl Werner Otto Fritz Franz Wien, Nobel Prize winner Walther Hermann Nernst, Nobel Prize winner Ernest Rutherford, 1st Baron Rutherford of Nelson, Nobel Prize winner Johannes Stark, Nobel Prize winner Frederick Soddy, Nobel Prize winner Percy Williams Bridgman, Nobel Prize winner Edwin Mattison McMillan, Nobel Prize winner Hideki Yukawa, Nobel Prize winner Hannes Olof Gösta Alfven and many other outstanding scientists.*

[5] *At that time, political and other considerations far from science began to influence the outcome of scientific discussions. Thus, decisions on banning criticism of the theory of relativity were made three times in the Soviet Union: in 1934, by the resolution*

thus, incomplete and imperfect STR in its existing version came into use as a generally acknowledged theory.

2. Unsuccessful OPERA experiment

In 1958 Pavel Alekseyevich Cherenkov, Igor Evgenievich Tamm and Ilya Mikhailovich Frank received the Nobel Prize for the discovery and interpretation of Cherenkov radiation [8], emitted when charged particles move through a transparent medium at a speed greater than the speed of light in that medium. Apparently, the discovery refuted the principle of light speed non-exceedance and, therefore, the existing version of the STR. However, over some time the principle was resurrected by revision stating that it implied movement of a physical body only in a vacuum.

Nevertheless, doubts about the truth of the principle of light speed non-exceedance have remained even in its revised version. In this regard, there was apparent necessity for an experiment that would be able to confirm or refute the principle of light speed non-exceedance in a vacuum, and thereby prove or refute the principle of physical reality of imaginary numbers. The OPERA experiment, aimed to detect superluminal neutrinos, would seem to be appropriate. On September 23, 2011 the OPERA collaboration published [9] a sensational report on registration of superluminal neutrinos contradicting the STR. However, on March 15, 2012 the ICARUS collaboration published [10] a report on refutation of the OPERA experiment. That has created illusion of irrefutability of the STR.

3. Alternative experimental proofs of physical reality of imaginary numbers

Creation of such illusion was presumably the true goal of the OPERA and ICARUS experiments. That is, the OPERA and ICARUS experiments were probably just an advertising campaign, which, in the absence of scientific arguments, was supposed to prolong existence of the incorrect STR version. And such an assumption seems quite plausible, since it is confirmed by facts. Results of experimental studies of special processes in linear electric circuits [11-16] that successfully proved physical reality of concrete imaginary numbers[6] and made OPERA experiment unnecessary were actually published in 2008-2010, i.e., prior to publication of OPERA experiment results. And along with subsequent experimental studies of such processes [17-26] they have never been refuted, unlike the OPERA experiment.

Publications [11-26] presented even three experimental proofs of physical reality of imaginary numbers:

- a proof using oscillatory transient processes [15-17], [18], [25], [26]. It implied that there would be no tsunami, pianos and church bells would not sound and even children's swing wouldn't sway after being pushed by parents, if the principle of light speed non-exceedance were true;
- a proof using oscillatory resonant processes [11-14], [16], [18], [19], [25], [26]. It implied that there would be neither television, nor radiolocation, nor GPS trackers, nor mobile phones, etc, if the principle of light speed non-exceedance were true;
- a proof using Ohm's law in the interpretation of Steinmetz [20-26], proposed in 1893 and known to all educated people. It implied that the principle of light speed non-exceedance could be refuted even before creation of the STR.

The proofs presented are quite simple and can be verified and confirmed in any radio engineering laboratory, and therefore are irrefutable. To make sure thereof, let's demonstrate one of them, for example, the last proof, since it is the simplest and clearest.

Recall that in accordance with the symbolic method of calculating electric circuits proposed by Steinmetz, which is now used by all electric and radio engineers, resistance is measured by real numbers, while capacitive and inductive reactance is measured by bipolar imaginary numbers. Consequently, impedance of electric circuits containing resistors, capacitors and inductors is measured by complex numbers. Thus, if, in accordance with the principle of light speed non-exceedance, imaginary capacitive and inductive reactance were actually imaginary, i.e. physically non-existent, then electric circuit impedance would always be determined only by resistors and therefore, never depend on frequency. However, all engineers have been aware for more than a hundred years that impedance of LCR circuit changes, as frequency of voltage applied thereto varies. This is due to change in amount of current flowing through the LCR circuit. This unequivocally proves physical reality of imaginary reactance of capacitors and inductors, and thereby physical reality of any imaginary numbers.

Besides, if, according to the principle of light speed non-exceedance, imaginary reactance of capacitors and inductors were actually imaginary, then there would be no resonance in electric LCR circuits and electric filters could hardly be created. As a result, neither electric engineering, nor radio engineering, nor other exact sciences would exist. However, they do. And for more than a century, millions of engineers have used Ohm's law in the interpretation of Steinmetz in their daily practical activities, thereby proving physical reality of imaginary numbers, which physicists of 21st century still consider unproved on the basis of the unsuccessful OPERA experiment. Thus, using the principle of light speed non-exceedance postulated in the STR, physicists assert impossibility of existence of television, telecommunications, radar and radio navigation, impossibility of sounding of musical instruments and church bells, and deny existence of tsunami and even children's hanging swings.

of the Central Committee of the All-Union Communist Party (Bolsheviks) on the discussion of relativism; in 1942, by the resolution of the Presidium of the Academy of Sciences of the Soviet Union on the theory of relativity; and in 1964, by the closed decree of the Presidium of the Academy of Sciences of the Soviet Union that forbade all scientific councils, journals and departments to accept, consider, discuss and publish works criticizing the theory of Albert Einstein. In other countries, for example in Germany, the attitude to the STR was also ambiguous.

[6] *I.e. provided with references to units used to measure parameters of corresponding physical objects and processes.*

Therefore, it is high time for physics to recognize the fallacy of relativistic formulas developed in the existing version of the STR in the 20th century and the principle of light speed non-exceedance used to explain them.

4. Fallacy of the existing version of the STR

Now, having proved the principle of physical reality of imaginary numbers, we have a great opportunity to explain the meaning of relativistic formulas of the STR both in the range $0 \le v < c$ and $c \le v$. And since people think in visual images, we use the graphs (see Figure1a,b,c) of relativistic formulas to make the explanation more clear

$$m = \frac{m_0}{\sqrt{1-(v/c)^2}} \quad (1)$$

$$\Delta t = \Delta t_0 \sqrt{1-(v/c)^2} \quad (2)$$

$$l = l_0 \sqrt{1-(v/c)^2} \quad (3)$$

where m_0 is the rest mass of a physical body;

m is the relativistic mass of a moving physical body;

Δt_0 is the rest time of a physical body;

Δt is the relativistic time of a moving physical body;

l_0 is the rest longitudinal length of a physical body;

l is the relativistic longitudinal length of a moving physical body;

v is the velocity of a moving physical body;

c is the speed of light.

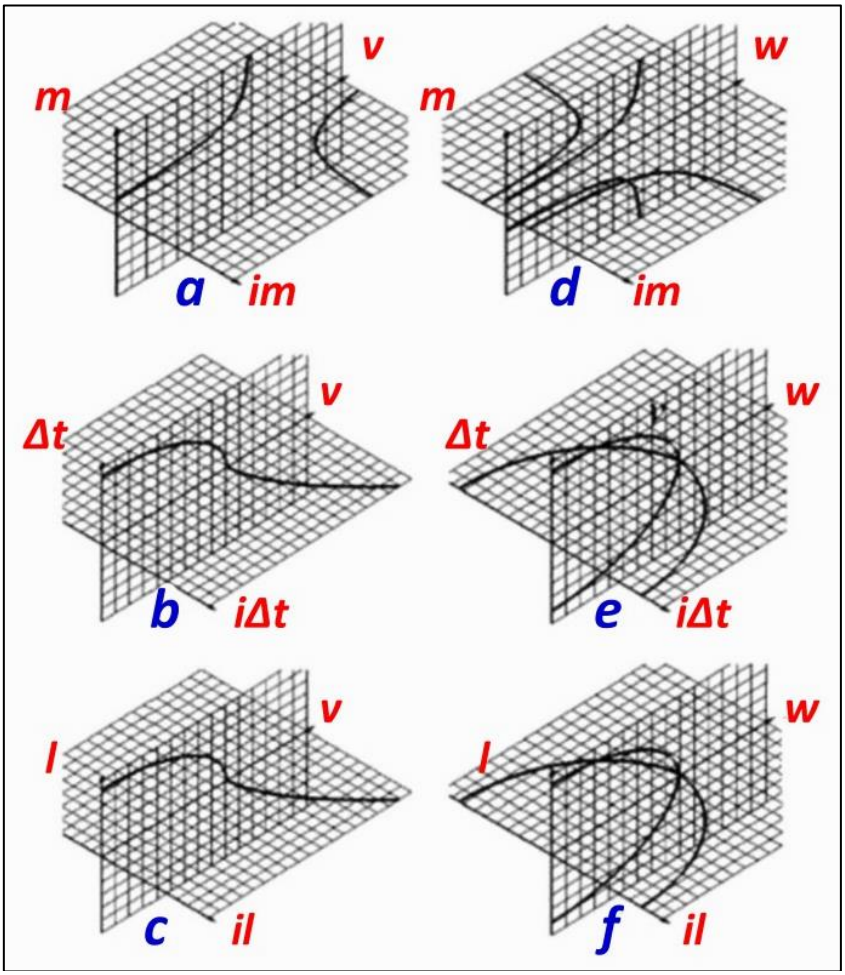

Figure 1. Graphs of functions (1) - (3), corresponding to the existing version of the STR, and (4) - (6), corresponding to its alternative version

As can be seen, fragments corresponding to the intervals $0 \le v < c$ and $c \le v$ are expressed in different forms on all these graphs. But according to the principle of physical reality of imaginary numbers, both intervals should still correspond to really existing universes, albeit different: the interval $0 \le v < c$ should correspond to our visible universe, and the interval $c \le v$ to some other invisible universe that lies beyond the horizon of events. However, an invisible universe corresponding to the interval $c \le v$ is inexplicable, since it corresponds to a process that cannot exist in nature.

Hence, logical conclusion is that the formulas (1) - (3) are false. Consequently, the ***existing version of the***

STR is also false. So, we have to admit that the STR was not actually created in the 20th century. Moreover, it could not be created at that time, since experimental data required for its creation were obtained only in the 21st century.

And such a result is even expected in creation of the STR. Physical truth can be guessed by no postulates, if its search is not corrected by appropriate experiments[7]. That's why the Nobel Prize winner Stephen Weinberg was right in his statement concerning postulate-based theories: *"Scientific theories cannot be deduced by purely mathematical reasoning".*

We would add that any postulate in physics should sooner or later be replaced by either confirming or refuting experiment. Theories containing postulates are rather hypotheses.

5. Truth of the alternative version of the STR

Graphs shown in Figure 1d,e,f should correspond to the explainable relativistic formulas of the STR [27] and the following formulas

$$m = \frac{m_0 i^q}{\sqrt{1-(v/c-q)^2}} = \frac{m_0 i^q}{\sqrt{1-(w/c)^2}} \quad (4)$$

$$\Delta t = \Delta t_0 i^q \sqrt{1-(v/c-q)^2} = \Delta t_0 i^q \sqrt{1-(w/c)^2} \quad (5)$$

$$l = l_0 i^q \sqrt{1-(v/c-q)^2} = l_0 i^q \sqrt{1-(w/c)^2} \quad (6)$$

where $q = \lfloor v/c \rfloor$ is the 'floor' function (Figure 2a) of argument v/c;

$w = v - qc$ is the local velocity (Figure 2b) for each universe, which can take values only in the range $0 \le w < c$;

v is the velocity measured from our visible universe.

The parameter q in the formulas (4) - (6) means the fourth spatial dimension, whose integer values in the Multiverse correspond to the coordinates of mutually invisible universes [28], [29] included therein. Therefore, such a Multiverse is referred to as hidden. In the hidden Multiverse, different q values correspond to the following universes:

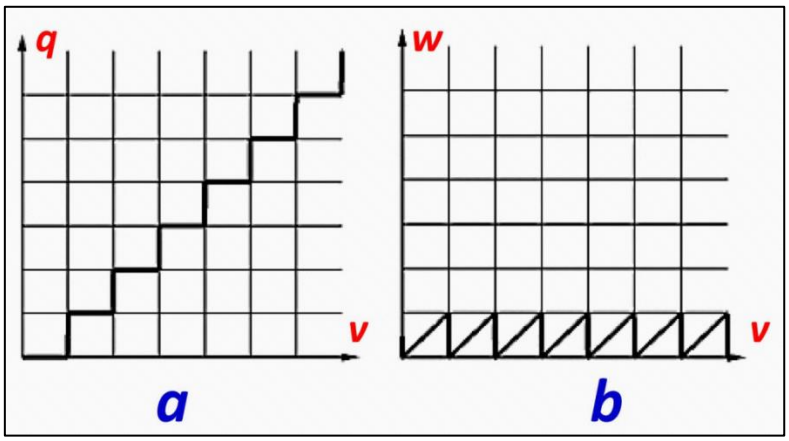

Figure 2. Graphs of functions $q(v)$ *and* $w(v)$

- the quantity $q = 0$ corresponds to our visible universe (as $i^0 = 1$ and, therefore, $0 \le v < c$ for it), which is referred to as tardyon due to the name of subatomic particles moving at sub-light speed;
- the quantity $q = 1$ corresponds to an adjacent invisible universe (as $i^1 = i$, and, therefore, $c \le v < 2c$ for it, that is, it is located beyond the event horizon), which is referred to as tachyon due to the name of subatomic particles moving at hyper-light speeds;
- the quantity $q = 2$ corresponds to an invisible tardyon antiverse (as $i^2 = -1$, and, therefore, $2c \le v < 3c$ for it, that is, it is also located beyond the event horizon), since according to the relativistic formulas (4) - (6) all its physical quantities take on values opposite in sign to those of the same quantities in a tardyon universe;
- the quantity $q = 3$ corresponds to an invisible tachyon antiverse (as $i^3 = -i$, and, therefore $3c \le v < 4c$ for it, that is, it is also located beyond the event horizon), since according to the relativistic formulas (4) - (6) all its physical quantities take on values opposite in sign to those of the same quantities in a tachyon universe;
- the quantity $q = 4$ corresponds to another invisible tardyon universe (as $i^4 = 1$, and, therefore, for it, that is, it is also located beyond the event horizon), since according to the relativistic formulas (4) - (6) all its physical quantities take on the same values as those of the quantities in a tachyon universe, for which

[7] *Therefore, for example, the WMAP and Planck experiments (see below) turned out to be unguessed.*

$4c \le v < 5c$;

- the quantity $q = 5$ corresponds to another invisible tachyon universe (as $i^5 = i$, and, therefore, $5c \le v < 6c$ for it, that is, it is also located beyond the event horizon), since according to the relativistic formulas (4) - (6) all its physical quantities there take on the same values as those of the quantities in a tardyon universe, for which $q = 1$, and so on.

Moreover, the universes of the hidden Multiverse have actually no fixed location in space. They continuously drift, touching and even slightly penetrating into each other. And adjacent invisible universes exchange their physical content through numerous transitional zones, called portals or star gates [30-33], generated at penetration points. As a result, over billions of years of existence, mass/energy of these universes has significantly averaged.

6. Explanation of the phenomenon of dark matter and dark energy

However, new ideas are worth something in science only if they allow solving new issues. In astrophysics, these are, for example, issues concerning explanation of the phenomenon of dark matter and dark energy, existence of antimatter and tachyons, experimental confirmation of existence of invisible universes, etc.

As it follows from the above, the idea of uniqueness of our visible universe, postulated[8] in the existing version of the STR, has failed a test.

Therefore, we shall check the idea of multiplicity of physical worlds, alternative to the idea of Monoverse, for compliance with the criterion of fruitfulness. Let's start with the phenomenon of dark matter, discovered by Jan Hendrik Oort [34] and Fritz Zwikky [35] in 1932-33, and the phenomenon of dark energy, discovered by Saul Perlmutter [36], Brian Schmidt [37] and Adam Riess [38] in 1998-1999. All of them were awarded the Nobel Prize for their discoveries. Stressing the importance of the discoveries, the Nobel Prize laureate Adam Riess wrote: *"Humanity is on the verge of a new physics of the Universe. Whether we want it or not, we will have to accept it".* Such a new physics is actually concerned below.

The phenomena of dark matter and dark energy [39-42] are referred to as such for their obscurity. It is not clear why they are invisible in any range of electromagnetic oscillations and therefore can only be detected indirectly by their gravitational manifestations. It is even more incomprehensible why no molecules, atoms and subatomic particles have so far been found in dark matter and dark energy. This is completely inconsistent with modern fundamental concepts of physical chemistry as to the essence of matter. Many other things also remain an enigma. Therefore, explanation of the phenomenon of dark matter and dark energy is the most important issue of modern physics.

Professor Michio Kaku commented on this issue as follows: *"Of course, a whole bunch of Nobel Prizes is waiting for scientists who can reveal the secrets of the "dark energy" and "dark matter"".*

Albert Einstein explained very clearly the reason for obscurity of the phenomenon of dark matter and dark energy in the existing version of the STR: "*Insanity: doing the same thing over and over again and expecting different results".* Sir Isaac Newton was of the same opinion: *"No great discovery was ever made without a bold guess".*

That is, astrophysicists created all these obscurities by wrong formulation of the problem. They sought an explanation of this phenomenon, which would certainly correspond to the existing version of the STR, stating that we live in the Monoverse. They thought that any alternative explanations for this phenomenon were of no interest. After all, even a few attempts to study possible structures of the Multiverse [43-49] have still been commented on as fundamentally unverifiable.

However, the phenomenon of dark matter and dark energy becomes quite explicable [50-58] as soon as problem formulation is changed and explanation is sought within the hidden Multiverse:

- dark matter and dark energy are not real physical entities that can be found either in the microcosm or macrocosm. They are rather a certain image (gravitational, rather than optical and still less electromagnetic) of invisible universes of the hidden Multiverse, a sort of a shadow;
- dark matter is generated by parallel universes of the hidden Multiverse adjacent to our universe;
- dark energy is generated by other parallel universes of the hidden Multiverse, more distant from us;
- images corresponding to dark matter and dark energy have[9] no chemical composition. This alone suggests and proves existence of the Multiverse, rather than Monoverse;
- dark matter and dark energy are invisible because universes of the hidden Multiverse generating them are invisible.

Such an explanation meets the criterion of Occam's razor and therefore is quite correct.

7. Analysis of experimental data obtained by WMAP and Planck spacecraft

Extremely valuable additional information on the structure of the hidden Multiverse can be discovered in analysis of data obtained by WMAP [59] and Planck [60] spacecraft. Thus, according to Planck data, total mass/energy of the entire Multiverse contains 4.9% of ordinary baryonic matter (according to WMAP – 4.6%), 26.8% of dark matter (according to WMAP – 22.4%) and 68.3% of dark energy (according to WMAP – 73%). Therefore, we can conclude that:

- the entire Multiverse contains (100%)/(4,9%)=20,4 parallel universes according to Planck data (and (100%)/(4,6%)=21,8 parallel universes according to WMAP data);
- dark matter is generated by (26,8%)/(4,9%)=5,5 parallel universes according to

[8] *Since it follows from the postulated principle of light speed non-exceedance*

[9] *Try to find at least one molecule in any shadow*

Planck data (and (22,4%)/(4,6%)=4,9 parallel universes according to WMAP data);

- dark energy is generated by (68,3%)/(4,9%)=13,9 parallel universes according to Planck data (and (73,0%)/(4,6%)=15,9 parallel universes according to WMAP data).

And it's quite obvious that such experimental results could be guessed by no postulates in the 20th century.

8. The truth of the alternative version of the SRT (continued)

However ... the results obtained do not correspond to the relativistic formulas (4) - (6), since, according to WMAP and Planck data, our tardyon universe has five-six adjacent universes, rather than two. Consequently, the hidden Multiverse has actually three extra dimensions, rather than one.

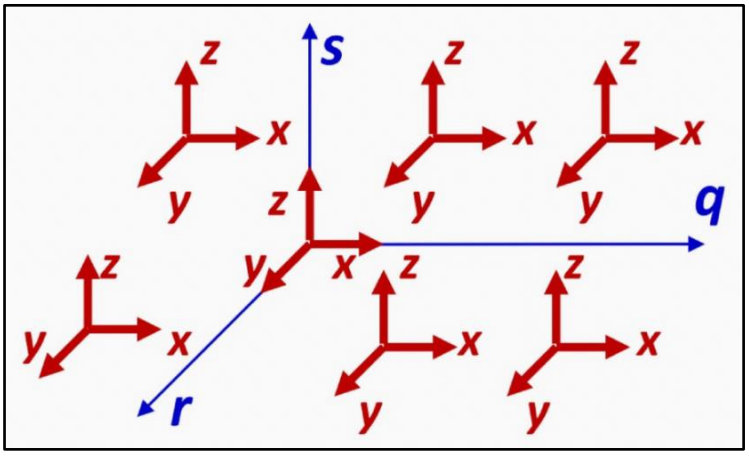

Figure 3. Six-dimensional space of the hidden Multiverse

Therefore, relativistic formulas of the STR (4) - (6) should be once more corrected as follows

$$m = \frac{m_0 (i_1)^{q-q_0} (i_2)^{r-r_0} (i_3)^{s-s_0}}{\sqrt{1-[v/c-(q+r+s-q_0-r_0-s_0)]^2}} = \frac{m_0 (i_1)^{q-q_0} (i_2)^{r-r_0} (i_3)^{s-s_0}}{\sqrt{1-(w/c)^2}} \quad (7)$$

$$\Delta t = \Delta t_0 (i_1)^{q-q_0} (i_2)^{r-r_0} (i_3)^{s-s_0} \sqrt{1-[v/c-(q+r+s-q_0-r_0-s_0)]^2} = \quad (8)$$

$$l = l_0 (i_1)^{q} (i_2)^{r} (i_3)^{s} \sqrt{1-[v/c-(q+r+s-q_0-r_0-s_0)]^2} = l_0 (i_1)^{q} (i_2)^{r} (i_3)^{s} \sqrt{1-(w/c)^2} \quad (9)$$

where q, r, s are the extra dimensions;

q_0, r_0, s_0 are the coordinates of our visible universe in the hidden Multiverse;

v is the velocity measured relative to our visible tardyon universe;

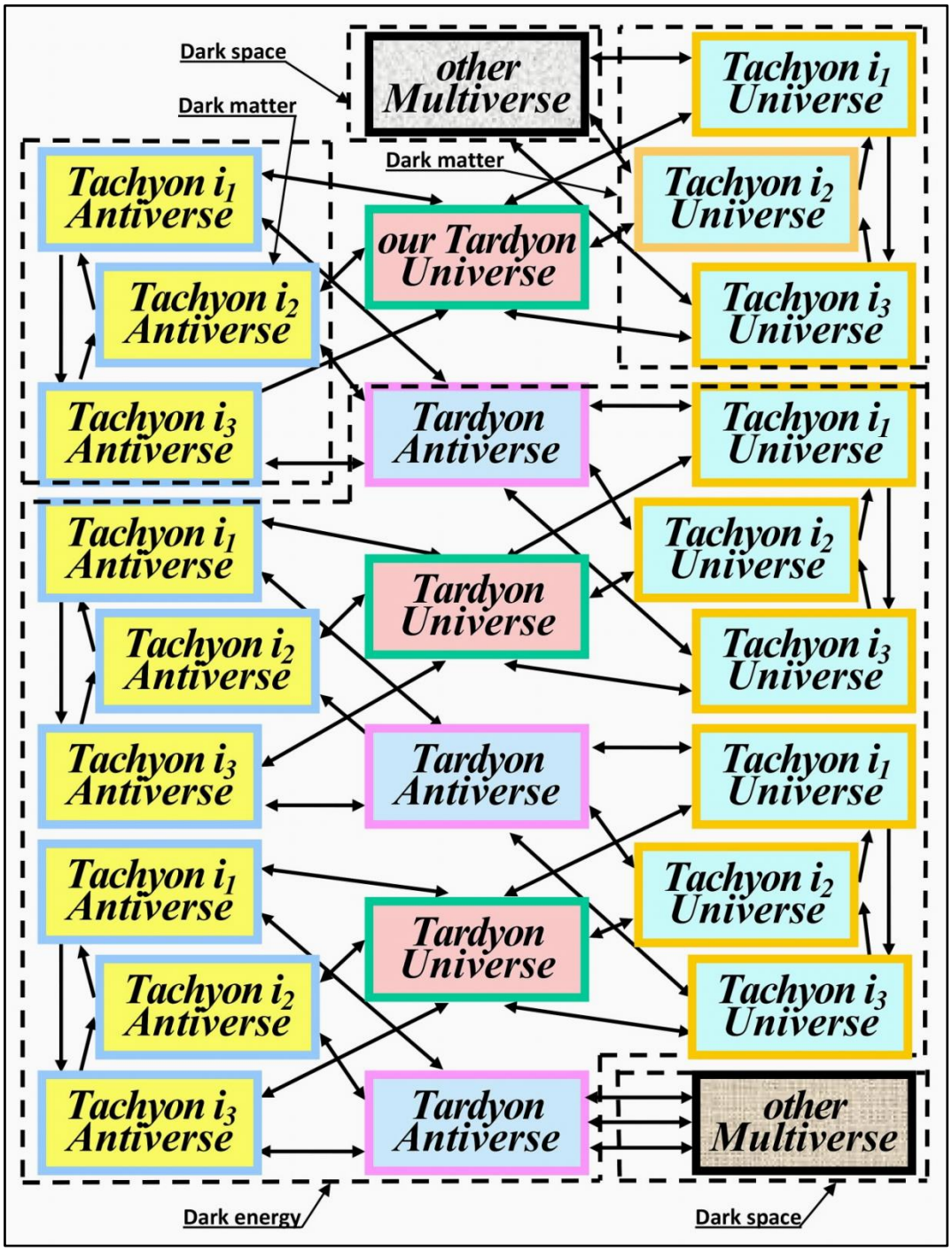

Figure 4. Probable quaternion structure of the hidden Multiverse in six-dimensional space

c is the speed of light;

$w = v - (q + r + s - q_0 - r_0 - s_0)c$ is local velocity of the universe corresponding to the coordinates i_1, i_2, i_3 that can take values only in the range $0 \le w \le c$;

i_1, i_2, i_3 are the imaginary units in hypercomplex numbers [61], called quaternions, that are interconnected by the following relations

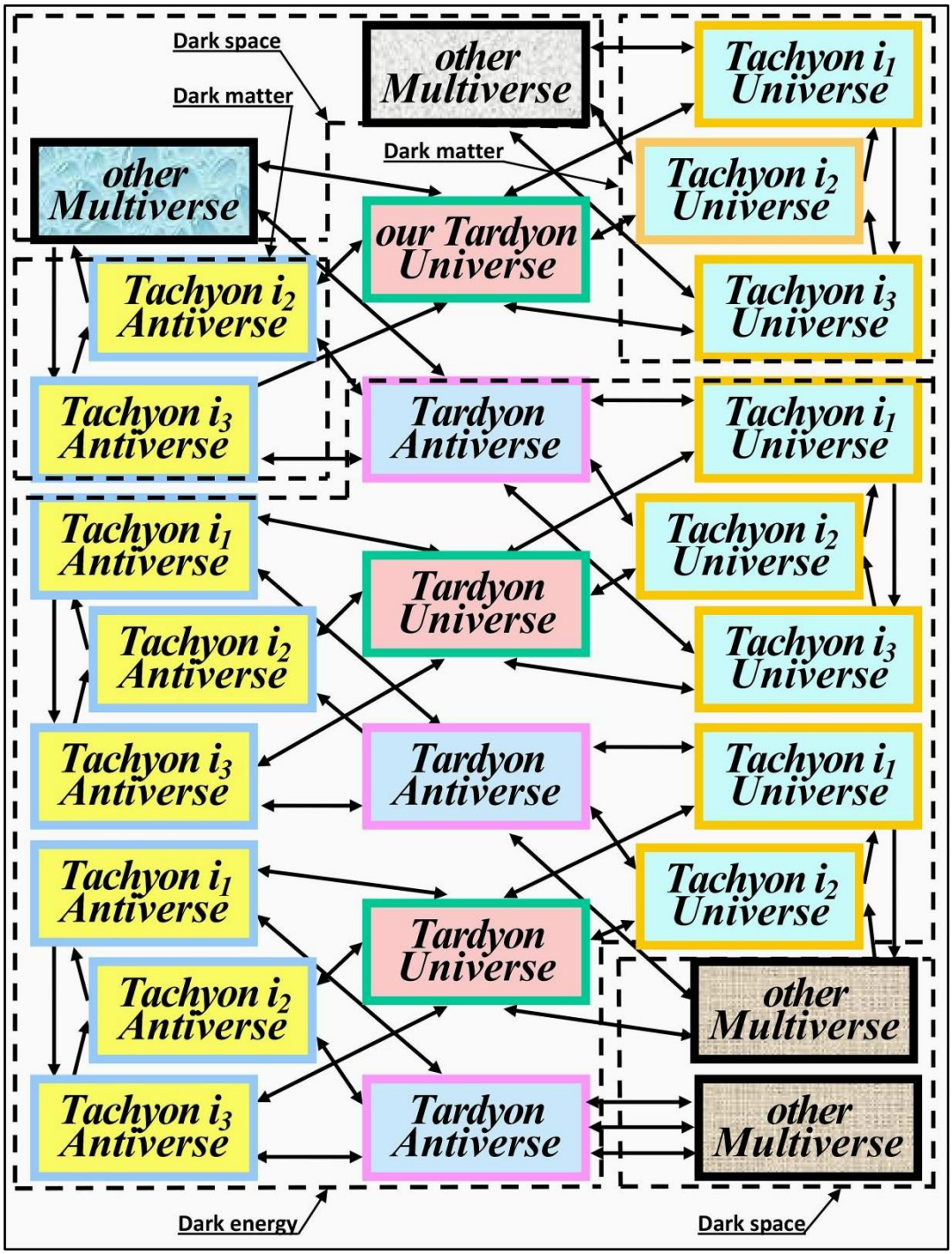

Figure 5. Possible quaternion structure of the hidden Multiverse in six-dimensional space

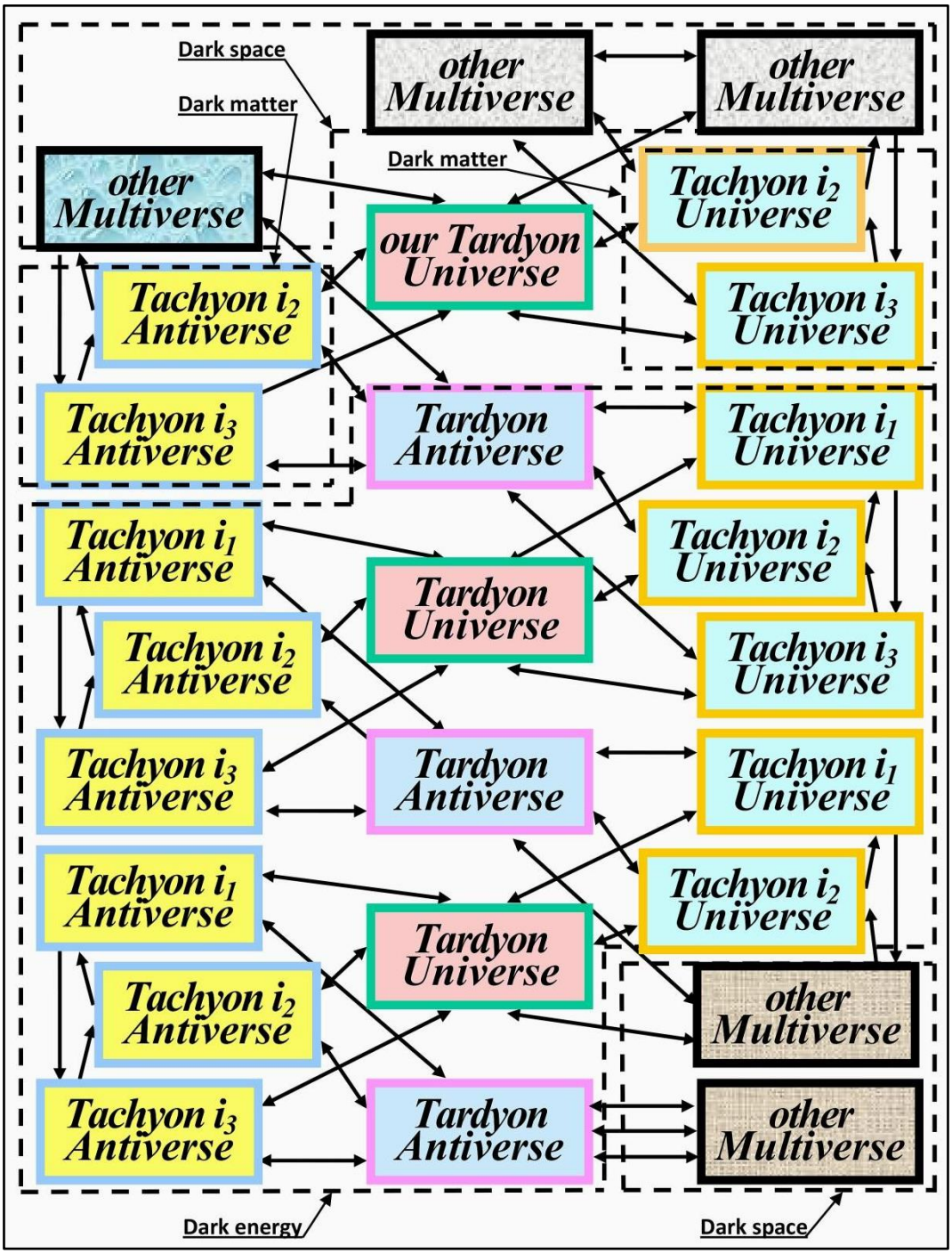

Figure 6. Another possible quaternion structure of the hidden Multiverse in six-dimensional space

$$i_1^2 = i_2^2 = i_3^2 = 1 \quad (10)$$

$$i_1 i_2 i_3 = i_2 i_3 i_1 = i_3 i_1 i_2 = -1 \quad (11)$$

$$i_1 i_3 i_2 = i_2 i_1 i_3 = i_3 i_2 i_1 = 1 \quad (12)$$

Consequently, structure of six-dimensional space (see Figure 3) of the hidden Multiverse [62] is described by the formula $f_{q,r,s}(x, y, z) + i_1 q + i_2 r + i_3 s$, where

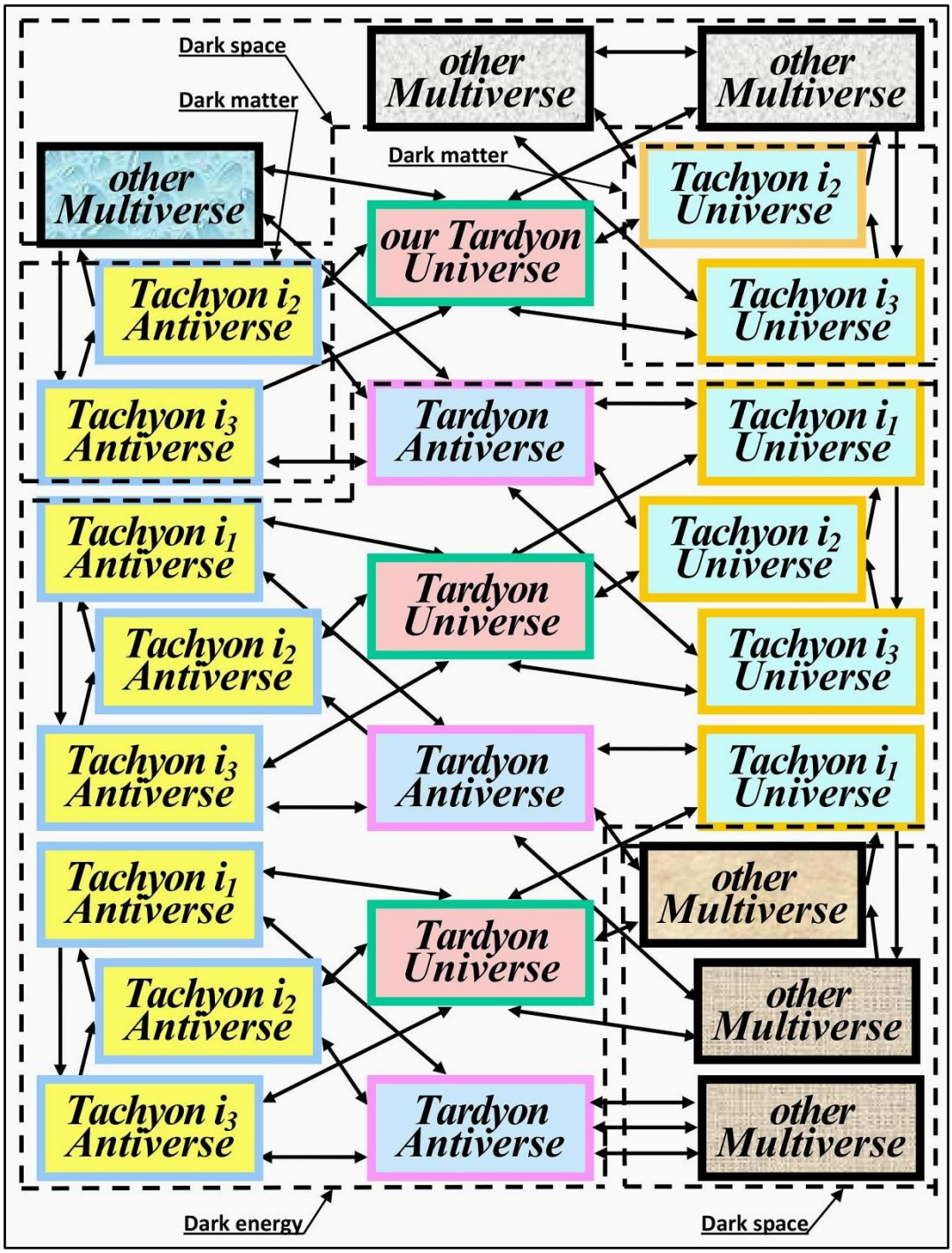

Figure 7. One more possible quaternion structure of the hidden Multiverse in six-dimensional space

- the term $i_1 q + i_2 r + i_3 s$ is the coordinates of the corresponding invisible universe,
- and the term $f_{q,r,s}(x, y, z)$ determines distribution of physical content in this universe.

Professor Lisa Randall suggested: *"We can be living in a three-dimensional space sinkhole in a higher-dimensional universe"*. And her suggestion actually proved true.

Therefore, the probable structure of the hidden Multiverse would seem to be as that shown in Figure 4. It has the following features:

- a screw structure containing three turns, eight universes in each;
- each turn contains one tardyon universe, one tardyon antiverse, three tachyon universes and three tachyon antiverses;
- the screw structure has a beginning and an end connected to the universes of other Multiverses through corresponding portals;
- other Multiverses along with our hidden Multiverse form the Hyperverse;
- invisible universes of the hidden Multiverse that are adjacent to our visible universe inexplicably evoke the phenomenon of dark matter;
- other invisible universes of the hidden Multiverse inexplicably evoke the phenomenon of dark energy;

- invisible universes outside the hidden Multiverse inexplicably evoke the phenomenon of dark space;
- universes of the hidden Multiverse are interconnected by bidirectional portals corresponding to the formula (10) and by unidirectional portals corresponding to the formulas (11) and (12).

This structure of the hidden Multiverse contains twenty-four universes. Therefore, it does not correspond to the results of WMAP and Planck data analysis.

Figure 5 shows possible structure of the hidden Multiverse corresponding to the results of WMAP and Planck data analysis and containing twenty-two parallel universes. If compared with the structure given in Figure 4, it lacks two invisible universes of the hidden Multiverse. Instead, adjacent invisible universes are connected through portals to invisible universes of two (or one) other Multiverses outside the hidden Multiverse. Besides, our hidden Multiverse can also be connected through portals with these other Multiverses in a different way.

Another possible structure of the hidden Multiverse containing twenty-one parallel universes is depicted in Figure 6. As can be seen, this structure lacks three invisible parallel universes. Instead, adjacent invisible parallel universes are connected through their portals to invisible parallel universes of other three (or two or one) Multiverses. At the same time, our hidden Multiverse can be connected through portals with these other Multiverses in a different way.

Finally, one more possible structure of the hidden Multiverse containing twenty parallel universes is depicted in Figure 7. This structure lacks four invisible parallel universes. Instead, adjacent invisible parallel universes are connected through portals to invisible parallel universes of other four (or three, or two, or one) Multiverses. At the same time, our hidden Multiverse can be connected through portals with these other Multiverses in a different way.

9. Antimatter and tachyons

Thus, an attempt to explain the phenomenon of dark matter and dark energy by existence of invisible universes can't be considered unsuccessful. Now let's see whether the same approach is useful in relation to the problem of explaining the existence of antimatter and tachyons [57], which until recently have been as inexplicable as dark matter and dark energy. Their explanation was hindered by such insurmountable contradictions, as the necessity of placing matter and antimatter in the Monoverse so that they did not annihilate and necessity of placing tachyons in the Monoverse so that they did not violate the principle of causality. As a result, the problems of explanation seemed completely unsolvable. And they are really unsolvable in the context of Monoverse corresponding to the existing version of the STR.

But why, then, taking into account these circumstances, has there been no attempt to abandon the principle of light speed non-exceedance and the Monoverse hypothesis following therefrom? Then it would have long ago become clear that relativistic formulas and the STR need correction.

One way or another, this has not been done. Therefore, we do it now. Explanation of these astrophysical problems appears to be extremely simple with a different approach. It has already been received. The explanation lies in the names of invisible universes of the hidden Multiverse. Antimatter in the hidden Multiverse exists in antiverses, which are as many as universes. Matter and antimatter do not annihilate in the hidden Multiverse, because its tardyon and tachyon universes and antiverses alternate in the above manner, i.e. are placed in different dimensions. Tachyons do not violate the principle of causality for the same simple reason: they are in tachyon rather than in tardyon universes and antiverses, i.e., also in different dimensions.

10. Discovery of the phenomenon of dark space

Noteworthy is the fact that some invisible universes evoking the phenomenon of dark matter and dark energy[10] shown in the structure diagrams of the hidden Multiverse (Figure 5-7), corresponding to WMAP and Planck data, are connected to invisible universes located outside the hidden Multiverse and evoking the phenomenon of dark space[11] (Figure 8a).

There is possibility that our visible universe is also connected to them (see Figure 8b). In that case it would become possible to study universes evoking the phe

[10] *For simplicity denoted as "dark matter" and "dark energy" in Figure 8*

[11] *For simplicity denoted as "dark space" in Figure 8b*

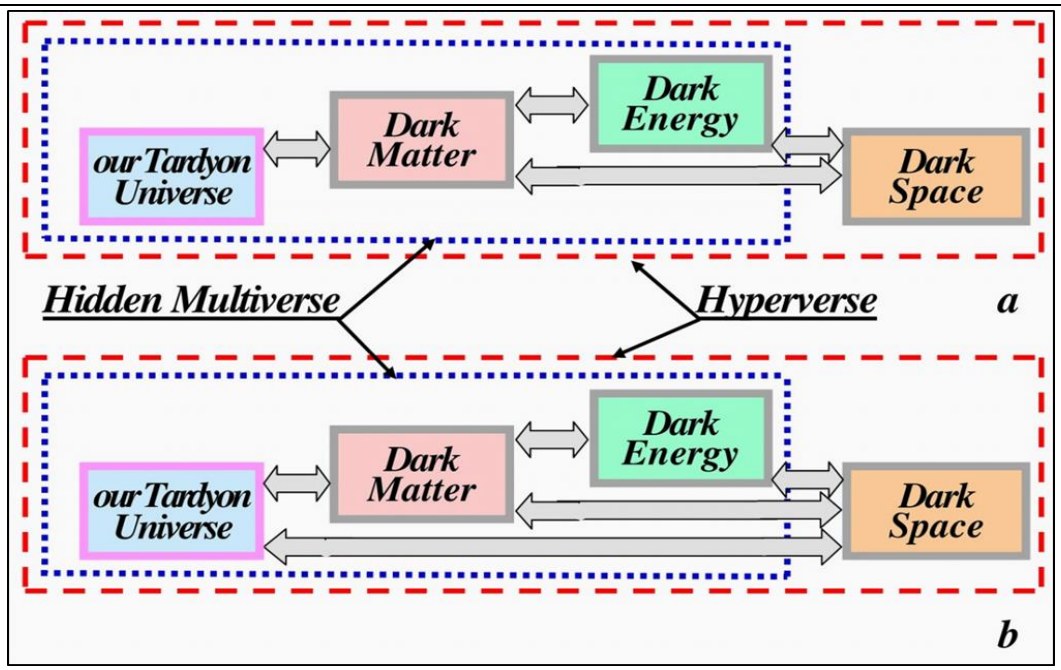

Figure 8. Possible structures of the Hyperverse

nomena of not only dark matter and dark energy, but also dark space [63-65]. However, which of these two structures actually exists is the question that can be answered only after astronomical research of invisible universes in portals on Earth described below. It should then become clear how many adjacent invisible universes our visible universe has and would be possible to study them somehow.

11. How to see constellations in the starry sky of invisible universes

It is plain to see that the above corrected version of the STR providing very clear explanation is based on the concept of real physical existence of invisible universes. However, despite its logical impeccability, it cannot be considered complete, until existence of invisible universes is proved experimentally.

So how physical reality of invisible universes can be proved? An experimentally supported answer to this question can actually be received only from appropriate astronomical observations. This appears to be simple. They only need to know places, where invisible universes are seen. Herewith, in order to understand that the universes we see are not our universe, but other universes that are invisible outside the portals, constellations in their starry sky should evidently differ from those in our visible universe. And it will not be difficult to verify this, since stars in different universes are most likely placed in extremely different ways[12] and, therefore, constellations of invisible universes and our visible universe are completely different.

To see the other constellations, we shall do the same thing as we do at home. To see what is going on in other invisible rooms from the room we are in, we need to come in other rooms or at least to come to the doors of these other rooms and look inside. Portals [30-33] are analogues of those doors. And the entrances to the ports are at least some of the many so-called anomalous zones [66].

Therefore, to see other constellations in the sky of other universes, which, one might recall, are invisible, we have to move on foot or by car to any of these adjacent invisible universes[13] through portals. Then the adjacent universe would become visi-

[12] *Like contents of different rooms in our home.*

[13] *Or at least to the portals connecting them.*

Figure 9. Main Astronomical Observatory of the National Academy of Science of Ukraine

ble to us, whereas our visible universe would become invisible. Such a journey through portals to adjacent invisible universes may be difficult and even dangerous[14] to implement, as one can get lost in portals and fail to find the way back. However, since, when moving through the portals, image of the starry sky of our universe is gradually replaced by images of the starry sky of adjacent universes, we wouldn't need to move too far into the portals. Those, it is enough to be in the anomalous zone. Even in this case, constellations in the starry sky of anomalous zones would noticebly differ from those on Earth outside the anomalous zones. Therefore, even the smallest changes in the configuration of the constellations registered in the anomalous zones will be the most indisputable proof of the existence of invisible universes.

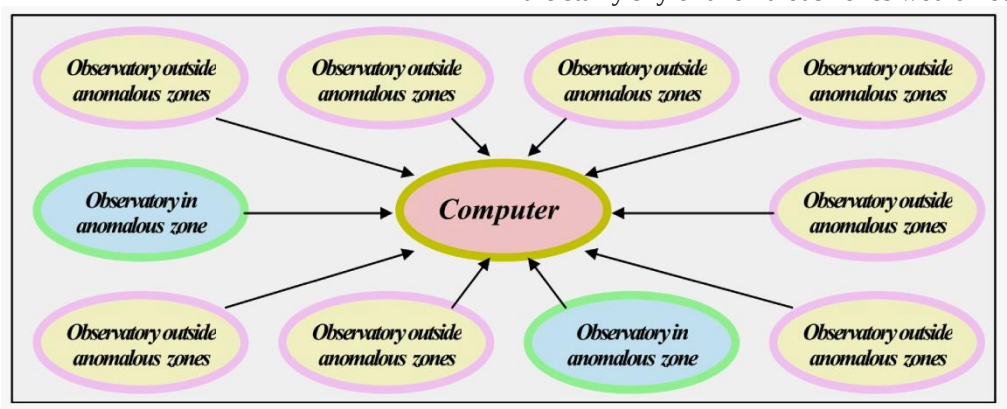

Figure 10. Scheme of an experiment to detect invisible universes

Thus, an experiment to discover invisible universes can be very simple, inexpensive, and short-time. In such an experiment, the main thing is to place the telescope in the anomalous zone. But since the constellations in the starry sky observed by such a telescope will differ slightly from the constellations observed by other telescopes located outside the anomalous zones, some astronomical observatories may be randomly placed in anomalous zones. As, for example, the Main Astronomical Observatory of the National Academy of Sciences of Ukraine (Fig. 9) is located 12 km from the center of Kiev in the Goloseevsky forest. In this case, the entire experiment will consist in comparing the positions of the stars of the same fragment of the starry sky, observed by different observatories, and detecting possible differences in their coordinates. To do this, all observatories will need to continuously transmit the relevant information to a single computing center (Fig. 10) and process it there to detect these differences.

Such an experiment would be simpler and more sensational than a similar experiment conducted by Sir Arthur Stanley Eddington in 1919 [67].

12. Invisible world

First, However, imaginary numbers are used not only in the STR. They are used in all other exact sciences. And it remains to be understood what physical sense they have in these sciences. Anyway, this circumstance proves that in addition to the visible world we

[14] *One should use (not yet existing) portal navigation devices similar to marine compass, in order not to get lost in portals, while moving therein. Such devices could use, for example, cellular telecommunication networks to determine relative attenuation of radio signals in accordance with the relativistic formulas (7) - (9) when moving away from portal entrance towards its exit. This would make it possible to determine correct direction of motion.*

know, there is also an invisible and unknown world.

Moreover, in the Euler's formula $exp(ix)=cos(x)+isin(x)$ describing oscillation processes, the real term $cos(x)$ of any physical nature (mechanical oscillations of a pendulum, acoustic oscillations generated by speech, sea waves, radio waves, etc.) is inextricably linked with the imaginary term $isin(x)$, physical sense of which is incomprehensible. It is clear that this circumstance proves not just existence of the invisible world, but also its interrelation with our visible world.

13. The principle of relativism

What is the contribution of Albert Einstein to the creation of new physics, physics of the future? Although much has been written about Albert Einstein, nothing has been written about the main thing – his role in creating new physics. This is because nobody needs new physics today. An old physics denying physical reality of imaginary numbers is now in demand, since the principle of light speed non-exceedance is still valid in spite of the above irrefutable arguments against the existing version of the STR. New physics, in contrast to the existing physics of real numbers, is the physics of imaginary numbers. This is the physics of invisible world. And it does exist, as the principle of physical reality of imaginary numbers has already been conclusively proved. It unambiguously refutes the principle of light speed non-exceedance. The existing version of the STR studied according to all textbooks of physics would collapse like a house of cards without the principle of light speed non-exceedance.

But Albert Einstein asserted: *"There is no single idea, which I would be sure that it will stand the test of time".* He understood that the postulate of light speed non-exceedance was short-lived and the STR version created in the 20th century was just a temporary intermediate option that would inevitably be corrected. Therefore, the phrase at the beginning of this article containing words "*relativistic formulas of the existing version of the STR are wrong and incorrectly explained, and conclusions drawn from them are misguided"* by no means detracts from the merits of Albert Einstein, who himself understood this very well: *"Anyone who has never made a mistake has never tried anything new".*

Albert Einstein created new things, even ahead of his time. Having no experimental data he needed in the 20th century, he had to replace them with postulates. He took the first step toward creating the alternative version of the STR by creating the existing incorrect version of the STR, although the formulas (1) - (3) turned out to be false. However, the correct formulas (7) - (9) and the alternative correct version of the STR would not been created soon, if the formulas have not been given in all physics textbooks and the existing incorrect version of the STR has still been not studied according to these textbooks.

Albert Einstein introduced the principle of relativism into physics, according to which some physical quantities may, under certain conditions, depend on other physical quantities. In the STR this is velocity dependence. Other similar dependencies will inevitably be revealed in the future. And in the future not only quantitative changes, as in the existing version of the STR, but also qualitative changes, as already in the alternative version of the STR, will be taken into account. For example, when water is heated to 99 °C it only remains hot, and upon reaching 100 °C, it turns into steam. Therefore, in the STR, when the velocity in the relativistic formulas (1) - (3) and (4) - (6) varies in the range $0 \le v < c$, there are only quantitative changes in physical quantities. However, in the alternative version of the STR, also above-mentioned qualitative changes take place at velocities $c \le v$. Consequently, the new physics is much more complicated than both classical physics and the existing version of the STR. However, it still remains to be created.

14. Conclusions

The article shows that the existing version of the special theory of relativity (STR) is incomplete. Its further development after Albert Einstein ceased due to the fact that the creators of the STR could not prove physical reality and explain physical sense of concrete imaginary numbers. Therefore, relativistic formulas obtained therein have been found to be incorrect and misexplained using the wrong principle of light speed non-exceedance. The relativistic formulas have entailed wrong conclusions consisting in existence of only our visible universe and absence of any real physical content in imaginary numbers. Ultimately, the ***existing version of the STR turned out to be wrong***.

The principle of light speed non-exceedance is refuted in the article by the experimentally proven principle of physical reality of imaginary numbers that makes the unsuccessful OPERA experiment unnecessary. Thus, the STR hypothesis on the uniqueness of our visible universe is also refuted. Our visible universe along with about twenty other mutually invisible universes is proved to form the hidden Multiverse.

The hypothesis of the hidden Multiverse makes it possible to explain the phenomenon of dark matter and dark energy. It is shown that dark matter and dark energy are a certain image (gravitational, rather than optical and still less electromagnetic) of the invisible universes, a sort of a shadow, rather than any physical substances. It is explained that the phenomenon of dark space is due to existence of other invisible universes of the Hyperverse.

It is also explained that ***existence of invisible universes can be proved experimentally***. This requires astronomical observations in the anomalous zones to register constellations in their starry sky that have never been noticed in the starry sky outside the anomalous zones. Moreover, constellations may be different in different anomalous zones. Therefore, they belong to different invisible universes.

Such experimental proof of existence of invisible universes, as well as experimentally proven principle of physical reality of imaginary numbers and the data obtained by the WMAP and Planck spacecraft ***manifest the truth of the alternative version of the STR.***

Finally, in addition to the visible world we know the corrected alternative version of the STR proves the

existence of invisible and, therefore, considerably unknown world that has yet to be studied by science of the future.

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APPLICATION OF HIGH ENTROPY COATINGS TO TURBINE BLADES FOR HEAT POWER PLANTS

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Abstract

In this paper, we review our work. Traditional nitride titanium coatings and highly entropic coatings from the unique magnetron targets synthesized by us were applied to the turbine blades.

Based on the above examples of the use of ion and ion-plasma assisting during or after deposition of coatings, it can be concluded that additional bombardment with gas or metal ions allows one to radically change the structure of the condensate. With ionic stimulation of coating growth, it is possible to increase the content of atomic and ionic components in the gas stream by reducing the molecular component.

Microhardness combined with a low coefficient of friction leads to good wear resistance of the CrNiTiZrCu coating. The application of such a coating to turbine blades showed a four-fold increase in service life. The coatings were made on parts made of steel 20X13. The very good characteristics of the coatings from the CrNiTiZrCu target are most likely due to titanium and zirconium nickelides. These compounds have the property of shape memory. The applied use of materials with memory is as follows: active devices are created that perform mechanical work due to heat. Such devices can serve as turbine blades, which are located on the rotating shafts. The memory alloy in such devices experiences various thermomechanical loads and can be restored due to reversible martensitic transformation. This results in reduced friction in the turbine blades.

Keywords: *highly entropic coatings, hardness, ductility, friction, wear resistance, nanostructure, microhardness, cathode, target, structure.*

Introduction

In turbines and compressors, blade mechanisms are usually used [1-3]. They consist of two types of blades [4, 5]:

- firstly, they are called working blades, because they are located on the rotating shafts, which during their rotation transmit kinetic energy, most often to the generator. Turbine blades are designed so that the pressure on the blades is always constant. Because of this, the difference in enthalpy is converted into flow energy;

- secondly, the guide vanes are located in the turbine housing. They are not completely, but due to the tangential force during rotation of the wheels, they transform the energy of the flow and the enthalpy decreases. This behavior of the difference in enthalpies is achieved by reducing the number of stages of the turbine blades.

The high degree of wear and tear of the main equipment in the energy sector sets the goal of increasing its life. Especially significant is the problem of increasing the service life of parts in contact with steam - turbine blades. The application of protective coatings on the working surfaces of turbine blades is the most effective way to increase their quality and durability [6-13].

In this paper, we review our papers [14–17]. Traditional nitride titanium coatings and highly entropic coatings from the unique magnetron targets synthesized by us were applied to the turbine blades.

Methodology for the preparation of research objects

Here we describe the mode of coating a turbine blade.

Preliminary preparation:

1. Visual inspection and preliminary cleaning of the scapula with coarse calico moistened with Nefras C2-80/120 in order to remove grease residues.

2. Cleaning and polishing the blades in the bath of the EPP-40 electrolyte-plasma polishing unit (Fig. 1), with the following parameters: the composition of the polishing solution is 5% aqueous solution of ammonium sulfate; solution temperature - 850 C; voltage cathode-anode 300 V, current 40 A; processing time 6 minutes

Figure 1 - Installation of electric pulse polishing EPP-40

Figure 2 - Ultrasonic bath for cleaning parts

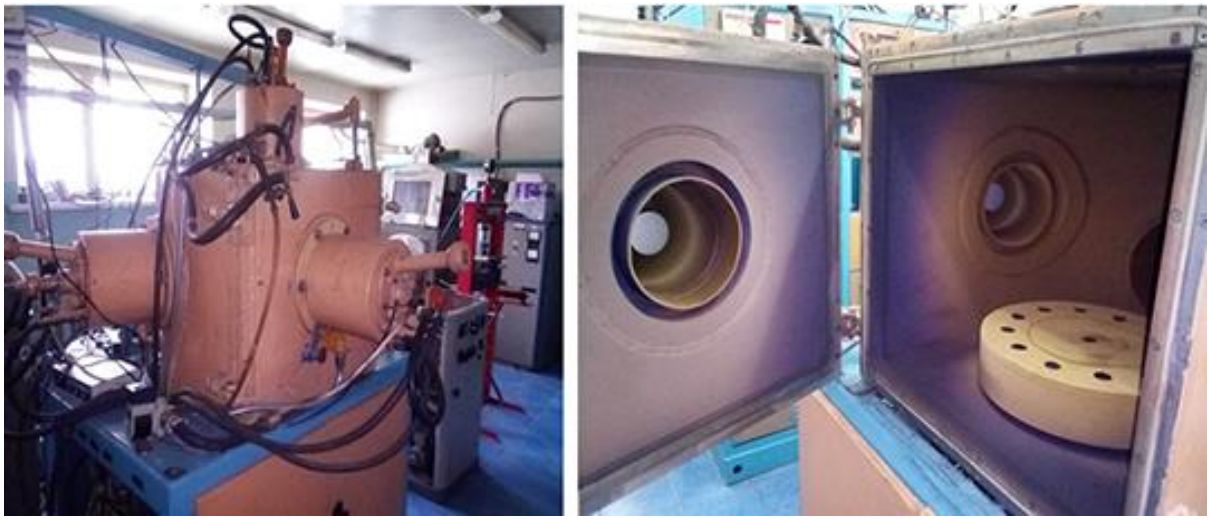
3. After unloading from the EPP-40 bath, the blade is washed in an ultrasonic bath (Fig. 2) and is steamed using the steam-jet device UPS 4.3-geyser (Fig. 3).

4. After steam-jet cleaning, the blade is wiped with coarse calico moistened with alcohol and placed in an oven to dry and preheat to 150 ^{0}C.

Figure 3 - Steam jet device UPS 4.3-geyser

Spraying process:

1. The prepared blade is installed in the vacuum chamber of the NNV 6.6-I1 installation (Fig. 4 a) by means of a snap on the satellite of a rotating table (Fig. 4 b).



a) *b)*

Figure 4 - Vacuum chamber of the NNV 6.6-I1 installation (a) and satellite of a rotating table (b)

2. Forvacuum pumping of the installation chamber to a pressure of 1 Pa is performed (time about 15 min.).

3. Further pumping of the chamber is carried out by a high-vacuum diffusion pump to a pressure of $5*10^{-3}$ Pa. (time 20-25 minutes).

4. Then, argon is poured into the chamber through the gas leak and the pressure in the chamber of $2*10^{-1}$ Pa is maintained using the BUEN electromagnetic leakage control unit.

5. To carry out the process of ionic cleaning and heating, a plasma source with an incandescent cathode of PINK is turned on, a filament current of 120 A and an ion current of 5A are set.

6. The reference voltage block is turned on and a bias voltage of -1000 V is applied to the part.

7. The table rotation drive is turned on and the rotation speed is set at 5 rpm.

8. Within 5-7 minutes. The PINK ion current is smoothly brought up to 65-70 A, and the blade heating is controlled using a Smotrich 7 pyrometer focused on the part through the camera inspection window.

9. When the temperature reaches 450 ^{0}C (time 20-25 min.), The flow of argon is stopped and high purity nitrogen is introduced into the chamber, while the pressure is maintained at $1.8\text{-}2.2*10^{-1}$ Pa.

10. Turn on electric arc evaporators (3 arcs) with installed titanium cathodes of the grade W 1-00, arc current 95 A, focusing coil current 0.3 A, stabilizing coil current 0.9 A.

11. The reference voltage is reduced to 250 V, PINK current 65-70 A.

12. At the established parameters, in the deposition mode with ion assisting, titanium nitride coating forms on the surface of the blade.

During the coating process, constant temperature control is required. When lowering the temperature from 450 ^{0}C to 420 ^{0}C, it is necessary to increase the temperature by briefly increasing the reference voltage to 1000 V. The duration of coating is 2 hours. With the specified spraying parameters, the coating thickness is 10-12 microns.

13. After spraying is completed, arc evaporators are turned off and additional coating nitriding is performed, for which the bias voltage rises to 500 V, the ion current of PINK 60 A is 20 minutes.

14. Then the gas supply is stopped, the PINK is turned off, the reference voltage is stopped, the rotation of the table is turned off, and when the blade reaches a temperature of 150 °C, atmospheric air is let into the chamber and the blade is unloaded.

As a result, the turbine blades have the form of titanium nitride coatings (Fig. 5).

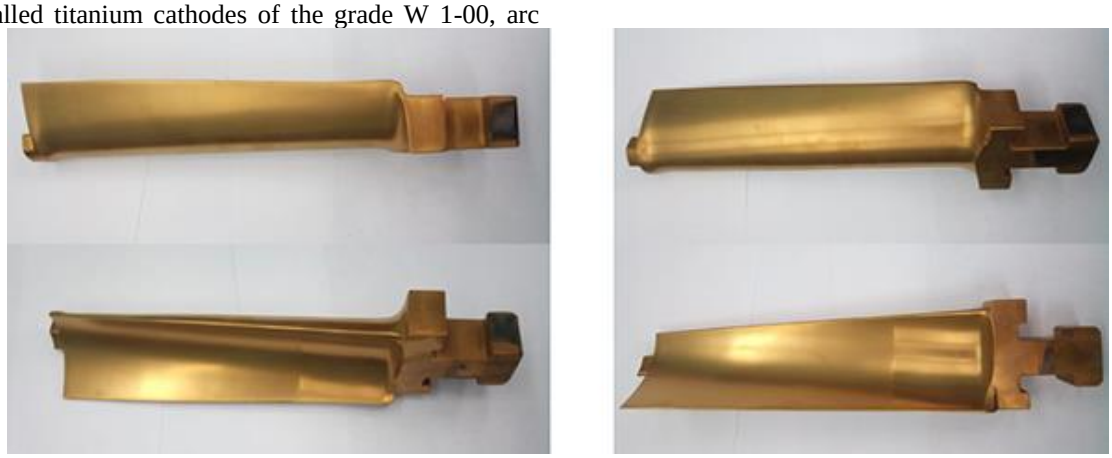


Figure 5 - Turbine blades with titanium nitride coating

Here we describe the method for preparing the CrNiTiZrCu target of a slightly different type than that used in our work [14]. However, the chemical composition of the coatings remains the same.

Preliminary production of the target:

1. We take a sheet of stainless steel 6 mm thick, draw a circle with a diameter of 102 mm on it.

2. Cut off all the excess as close as possible to the diameter of the circle we need. (30 min)

3. We fix the resulting polygon into a lathe and cut off all faces with a cutter, getting the round target we need with a diameter of 102 mm. (15 minutes)

4. Knowing from the working targets the diameter of the magnetron picking up the metal from the target, on the obtained round target we draw circles for milling the seats for tablets consisting of a highly entropic composition. Diameter 30 mm and 55 mm.

5. The diameter of the tablets is 12.5 mm. Accordingly, they include 13 pieces on the outer row and 7 pieces on the inner row with a small distance between the tablets.

6. We fix the target on the milling machine and milling with a milling cutter with a diameter of 12.5 mm seats for tablets to a depth of 4 mm (2 hours) (Fig. 6 a).

Tablet manufacturing process:

1. We take pure micropowders of Cr, Ni, Ti, Zr, Cu in equal proportions of 12 grams, at the rate of 3 grams of powder for the manufacture of one tablet (20 tablets).

2. Pour grinding balls of tungsten carbide in a proportion of 1/10 (powder / balls) into grinding tungsten carbide mortars, pour micropowders of 6 grams on top into 2 stupas (for centering the mill) and pour alcohol above the grinding level for wet grinding balls.

3. We close grinding stupas with covers and fix them in a ball mill.

4. Turn on the mill and set the speed to 500 rpm. (4 - 5 hours)

5. We take out the grinding stupas, open and pour through the sieve (to separate the balls from the emulsion) the emulsion obtained from micropowders into a clean container.

6. We wait until micropowder settles to the bottom. (1 hour).

7. Drain as much alcohol as possible into another container.

8. Wet micropowder put in a drying oven at a temperature of 70 ° C (30 min.).

9. The resulting dry powder is poured into a crucible and put in a vacuum oven with a temperature of 100 ° C and a vacuum of 5 * 10-3 Pa. (3 hours) (Fig. 6 b).

10. We take out the powder from the vacuum oven, measure it on a scale of 3 grams per tablet, and use the press and mold to make tablets. (1 hour)

11. The resulting tablets are baked in a vacuum oven with a temperature of 800 ° C in a vacuum of 5 * 10-3Pa. It is baked at a temperature of 800 ° C - 1 hour (heating / cooling - 6 hours) (Fig. 6 c).

12. Using a press, we press tablets into the seats of the fabricated target. (15 minutes) (Fig. 6 g)

Coating was carried out on prepared turbine blades made of steel grade 20X13. The vacuum chamber was pumped out to a pressure of 0.003 Pa, then the PINK was turned on, and Ar was puffed up to a pressure of 1 Pa; a negative bias potential of 1000 V was applied to the substrate for 10 min. blades were cleaned and heated. After that, the argon pressure was lowered to 0.1 Pa and the magnetron was switched on. The displacement on the blades was reduced to 150 V, the magnetron current was kept constant at 3 A. The blades were located at a distance of 15 cm, the spraying time was 1 hour. Spinning turbine blades in fig. 7.

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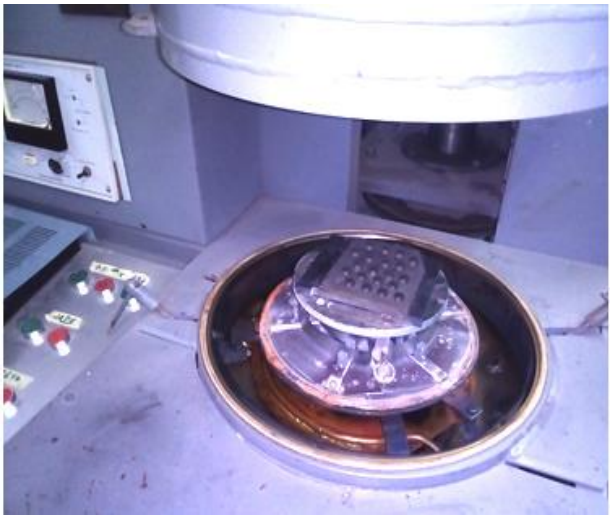
a)

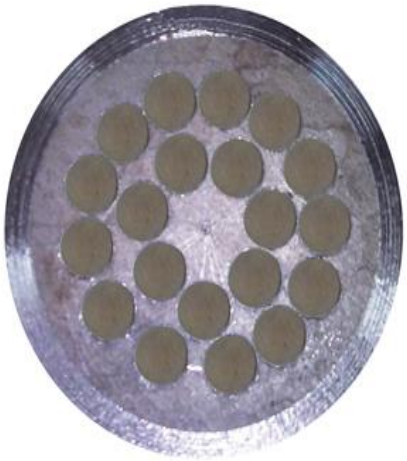
Stainless steel target for pills



b)

CrNiTiZrCu tablets in a vacuum oven

c)



g)

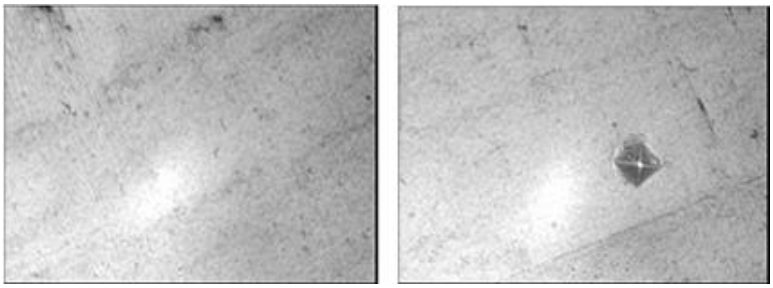
CrNiTiZrCu Alloy Tablets *Target with pills*

Figure 6 - Preparation of a CrNiTiZrCu Coating Target

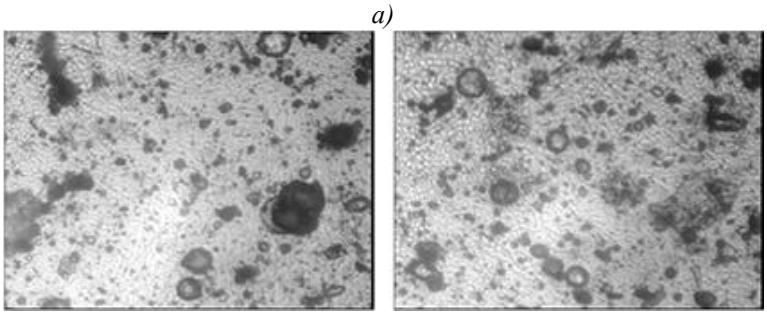
Figure 7 - CrNiTiZrCu Coated Turbine Blades

Discussion of the experimental results

In Figure 8 shows the results before titanium nitride coating on a 20X13 steel sample and after coating. The same results are shown in table. 1.



a)



b)

Figure 8 - The surface of the sample 20X13 without coating (a) and with a coating of titanium nitride (b)

Table 1 - Microhardness μ of a sample of a turbine blade without coating and coated with titanium nitride applied for 2 hours without PINK and with PINK assisted for 20 minutes at a load of HV 0.05 = 0.49N

μ, HV	271,5	263,1	258,7	254,2	269,4	258,4	263,1	**The average**	**263,3**
μ, HV	406,3	398,9	401,0	345,1	420,1	408,9	429,2	**The average**	**403,3**
μ, HV	986,3	823,9	857,0	883,1	996,2	883,6	854,1	**The average**	**909,3**

From the table. 1 it follows that the assistance of PINK according to Scheme 13 leads to an increase in microhardness by more than 3 times compared with the initial sample and 2 times compared with the titanium nitride coating. Assisting PINK shows that the structure of the coating can be changed using ion bombardment. In fig. 9 shows a TiN coating image after irradiation with nitrogen.

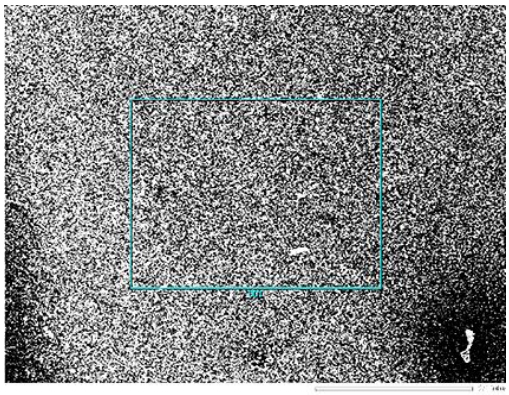


Figure 9 - Electron-microscopic image of the TiN coating after ion bombardment of sample 20X13 (compare with Fig. 8)

Irradiation of coatings using low-energy ion bombardment with nitrogen or argon leads to the appearance of nanocrystalline or submicrocrystalline structures. In this case, the phase and chemical composition does not undergo changes. Based on the above examples of the use of ion and ion-plasma assisting during or after deposition of coatings, it can be concluded that additional bombardment with gas or metal ions allows one to radically change the structure of the condensate. With ionic stimulation of coating growth, it is possible to increase the content of particles, both atoms and ions, in the gas flow by reducing the number of particles of molecules. In this case, the ion beam energy leads to an increase in the diffusion process, reducing the coating temperature and decreasing the size of crystalline particles.

Figures 10 show the chemical composition of the coatings CrNiTiZrCu, at. % in equiatomic proportions on turbine blades (table. 2).

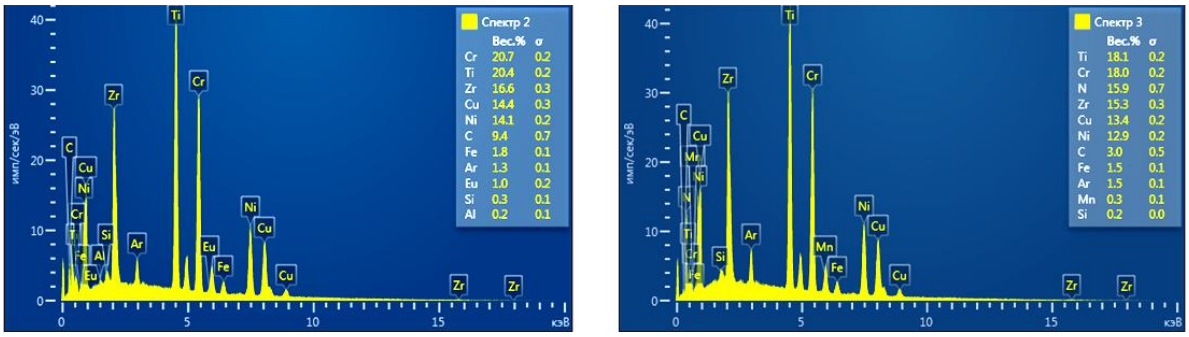


Figure 10 - XPS CrNiTiZrCu in argon at 2 points

Table 2 - Quantitative chemical composition of the coating CrNiTiZrCu, at. %

Element	Cr	Ni	Ti	Zr	Cu
Nominal	20	20	20	20	20
in argon	23,2	21,2	19,9	17,1	6,8

The microhardness measurements of CrNiTiZrCu coatings are given in Table. 3.

Table 3 - Microhardness of CrNiTiZrCu Coating on Turbine Blades

Microhardness	1	2	3	4	5	6	7	8	Среднее
HV	839	909	964	842	967	853	921	902	906

In modern experimental tribology, methodologies of kinetic contact interaction by a pin or a ball with a plane are widely used. In particular, the methodological features and requirements of wear tests of the type "pin on the disk" and "ball on the plane are set out in international standards. However, this methodology is not effective for studying the wear resistance of coatings and substrates and determining the thickness of thin coatings. To solve these problems, an effective method of testing for microabrasive wear is applied by applying a rotating steel ball to a flat sample with the addition of an emulsion containing abrasive particles (Fig. 11). At the point of contact, a crater of a spherical shape is formed - a calotte, therefore the device for providing this type of test was called a calotester. The results of studies of coatings CrNiTiZrCu are shown in table. 4.

Table 4 - Wear resistance of CrNiTiZrCu coatings on turbine blades

Sample wear (weight in grams) 30 min each						
Before	15,14852	15,14857	15,14859	15,14856	The average	15,148566
After	15,14745	15,14763	15,14759	15,14759	Difference	0,000986

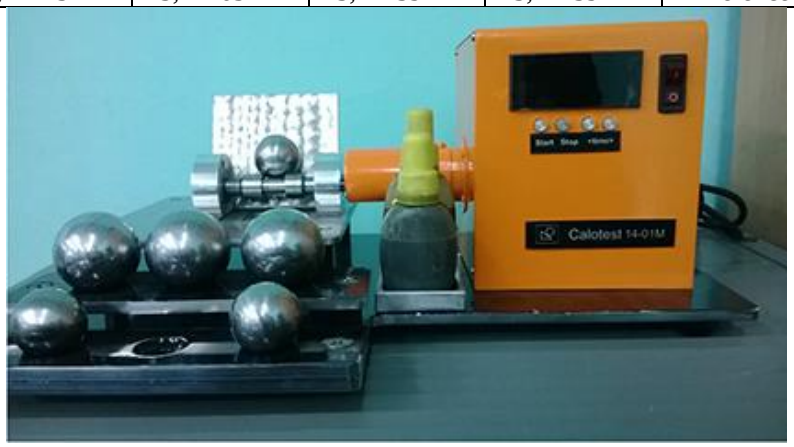


Figure 11 - A device developed by us for testing materials and coatings for microabrasive wear

Table 4 shows the wear resistance of the coating CrNiTiZrCu ~ $3 \cdot 10^{-4}$ g/min, which corresponds to wear-resistant coatings.

Such wear resistance of the CrNiTiZrCu coating means that the coating structure is not only highly entropic, as evidenced by the chemical composition from Table. 2, but also ordered. The ordering of the coating usually corresponds to dissipative structures. These structures, in contrast to structures in equilibrium, require an influx of energy from the medium (magnetron deposition of the coating). Not surprisingly, dissipative structures arise only in systems that are in conditions closer to critical. The return of such a structure to the equilibrium state is due to the instability of the nonequilibrium state. Such a transition between states can occur if the system parameter is higher than critical. After such a transition from a disordered state, dissipative structures to a new equilibrium state become stable.

In our work [18], violations in a solid or in a surface layer, a coating, are considered as a system of particles without interaction, which is located in a thermostat. The interaction of particles with a thermostat corresponds to dissipative quantum transitions (with probability P) versus the interaction of particles with an external field (with probability F). In this paper [18] we obtained the following formula:

$$P = \frac{2\Delta S}{k\tau} \exp\left\{-\frac{E_m - G^0/N}{kT}\right\}. \quad (1)$$

where ΔS is the change in entropy in the dissipative process; E_m is the average energy of the ground state of defects; τ is the relaxation time, G^0 is the Gibbs energy, N is the concentration of defects, k is the Boltzmann constant.

The probability of dissipative processes is defined on the other hand as the ratio of the fracture energy Ep to the energy of the deposited coating E_p. We replace the exponent numerator with kT, and the denominator with kT_m. We further take into account that $\Delta S/k = \Delta H/kT_m$ (ΔH is the enthalpy or latent heat of fusion - L_m). The relaxation time of the phonon subsystem is [19]:

$$\frac{1}{\tau} = \sqrt{\frac{E(1-\nu)}{\rho(1+\nu)(1-2\nu)}}, \quad (2)$$

where E is Young's modulus; ν is the Poisson's ratio; ρ is the density.

Our strength (wear resistance) criterion is expressed as:

$$E_p = \frac{2L_m E_{on}}{kT_m}\sqrt{\frac{E(1-\nu)}{\rho(1+\nu)(1-2\nu)}}\cdot\left(1-\frac{T}{T_m}\right). \quad (3)$$

In the adiabatic approximation:

$$E_p = \frac{2L_m E_{on}}{kT_m}\sqrt{\frac{E(1-\nu)}{\rho(1+\nu)(1-2\nu)}}. \quad (4)$$

Equation (4) for the coating is approximately equal to:

$$Å_ð \approx Å_ñ = \sigma \cdot S, \quad (5)$$

where σ is the surface tension (surface energy), S is the surface area.

So, basically, the wear resistance of a high-entropy

coating is determined by surface tension. To determine the surface tension of a medium, it is necessary to have the mobility of the components (atoms, molecules) of this medium, which in the case of solids cannot be achieved, except for a temperature close to the melting point of metals. Surface tension is determined by the work of forming a new solid surface.

In [20], we proposed methods for determining the surface tension of deposited coatings. The first method provides for the measurement of surface tension by determining the dependence of microhardness on the thickness of the deposited coating. The dependence of the microhardness of the deposited coating on its thickness is described by the formula:

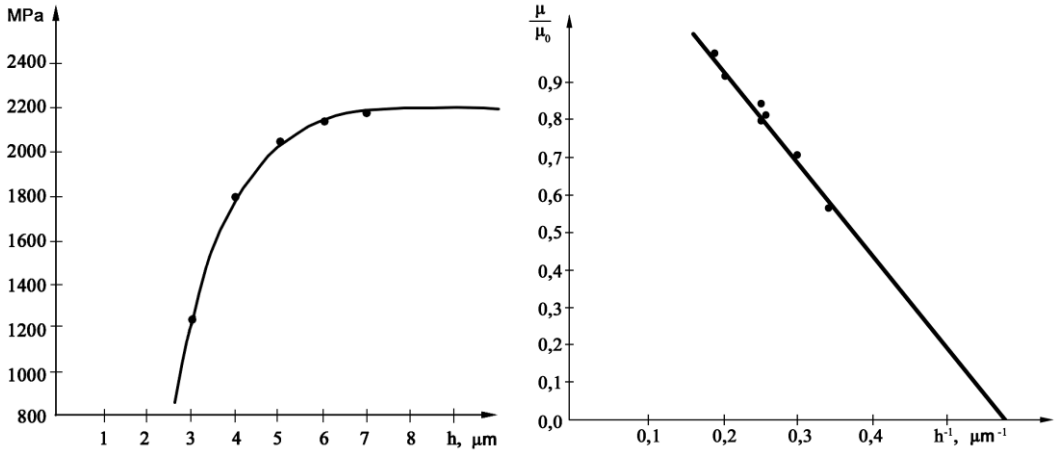
$$\mu = \mu_0 \cdot \left(1 - \frac{d}{h}\right), \qquad (6)$$

where μ is the microhardness of the deposited coating; μ_0 - "thick" sample; h is the thickness of the deposited coating. The parameter d is related to the surface tension σ by the formula:

$$d = \frac{2\sigma\upsilon}{RT}, \qquad (7)$$

where σ is the surface tension of the bulk sample; υ is the volume of one mole; R is the gas constant; T is the temperature. In coordinates μ ~ 1/h (1/h is the inverse thickness of the deposited coating), a straight line is obtained, the slope which determines the d, and the surface tension of the deposited coating (σ) is calculated by formula (7).

As an example, consider the determination of the surface tension of a CrNiTiZrCu coating on steel 20X13 (turbine blades). The results are shown in Figure 12..



a) *b)*

Figure 12 - Dependence of microhardness on the thickness (a) and inverse thickness (b) of the CrNiTiZrCu coating on steel 20X13 (turbine blades).

In the coordinates $\mu/\mu_0 \sim 1/h$, the experimental curve is straightened in accordance with formula (6), giving a value of h = 1.3 μm. For coating CrNiTiZrCu on steel 20X13 for surface tension, $\sigma = 1.149$ J/m^2. This value confirms the wear resistance of the CrNiTiZrCu coating on steel 20X13.

Conclusion

Based on the above examples of the use of ion and ion-plasma assisting during or after deposition of coatings, it can be concluded that additional bombardment with gas or metal ions allows one to radically change the structure of the condensate. With ionic stimulation of coating growth, it is possible to increase the content of atomic and ionic components in the gas stream by reducing the molecular component. The energy introduced by the ion beam can lead to an increase in the diffusion coefficient, which makes it possible to apply coatings at low temperatures, thereby reducing the grain size. In this case, due to the creation of defects on the surface of the film and driving in atoms and molecules of the evaporated metal, there is a forced generation of nucleation centers, which also reduces the grain size down to the nanometer scale.

Microhardness combined with a low coefficient of friction leads to good wear resistance of the CrNiTiZrCu coating. The application of such a coating to turbine blades showed a four-fold increase in service life. The coatings were made on parts made of steel 20X13. The very good characteristics of the coatings from the CrNiTiZrCu target are most likely due to titanium and zirconium nickelides. These compounds have the property of shape memory. The applied use of materials with memory is as follows: active devices are created that perform mechanical work due to heat. Such devices can serve as turbine blades, which are located on the rotating shafts. The memory alloy in such devices experiences various thermomechanical loads and can be restored due to reversible martensitic transformation. This results in reduced friction in the turbine blades.

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