

# THE IMPORTANCE OF EMOTIONAL INTELLIGENCE IN PATIENTS AND THEIR EFFECT ON POSTOPERATIVE WOUND HEALING

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**FACULTY OF MEDICINE**

**UNIVERSITY INTEGRATED UNDERGRADUATE AND GRADUATE STUDY OF  
MEDICINE IN ENGLISH LANGUAGE**

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The graduation thesis contains 20 pages, 2 figures, 2 tables, 39 references.

A big thank you to all my teachers and the faculty staff for educating, encouraging, and challenging me throughout the last 6 years here at the faculty.

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## **1. List of abbreviation and acronyms in alphabetical order**

- ANS: Autonomic nervous system
- ECM: Extracellular matrix
- EI: Emotional Intelligence
- GCs: Glucocorticoids
- HIF-1 $\alpha$ : Hypoxia inducible factor-1 alpha
- HPA: Hypothalamic-pituitary-axis
- IL: Interleukin
- IQ: Intelligence quotient
- NF $\kappa$ -B: Nuclear factor kappa B
- PNI: Psychoneuroimmunology
- QoL: Quality of life
- SAMA: Sympathetic-adrenal-medullary axis
- VEGF: Vascular endothelial growth factor

## **2. Introduction**

Wound healing in modern medicine is of great medical and economical interest. It has a significant impact on a person's quality of life as well as on the health care system and society as a whole (1, 2). It is an integral part of the healthcare system in inpatient as well as in outpatient settings (3). The topic of wound healing becomes relevant for every patient with major or minor surgery and is therefore of special interest for surgeons or any physician that performs some type of invasive care on a patient.

The economic interest becomes evident with a simple look at the costs related to wound healing. In the United States one diabetic ulcer can cost up to 50,000 USD and the annual cost for chronic wounds is estimated to be around 25 billion USD (1, 3). In developed countries the economic burden of wound care takes up to 3% of the total health care cost (2) but can be much higher in certain areas. For example, in Wales where the reported costs in 2012/2013 reached 6% of the total health care spendings. With those numbers in mind, it is evident that ideal wound healing is crucial for the future of financially sustainable healthcare (1).

Besides the direct costs resulting from wound care there are also indirect consequences that need to be considered. A patient's inability to work or a reduced productivity during the healing process can have further impacts on social economics (1). The risk of a reduced quality of life (QoL) for each patient that experienced a wound should also not be taken lightly, especially from the physician's point of view. Aesthetic or functional alterations can reduce one's QoL (4) and should be kept to a minimum in any patient treatment, as well as other wound complications. The relevance of postoperative wound healing is shown in a study on hemipelvectomy patients, where 34.1% had postoperative wound complications (5). Additionally, the rates of postoperative wound infections also show the relevance of adequate wound healing in patient care. Postoperative infections are a common problem and can significantly increase the morbidity and mortality of patients as well as the overall cost due to prolonged hospital stay (6).

With all this said the importance of good wound healing is unquestionable. This paper will try to find an alternative, more conservative way to improve wound management, by looking at the Emotional Intelligence in patients and how it can impact wound healing.

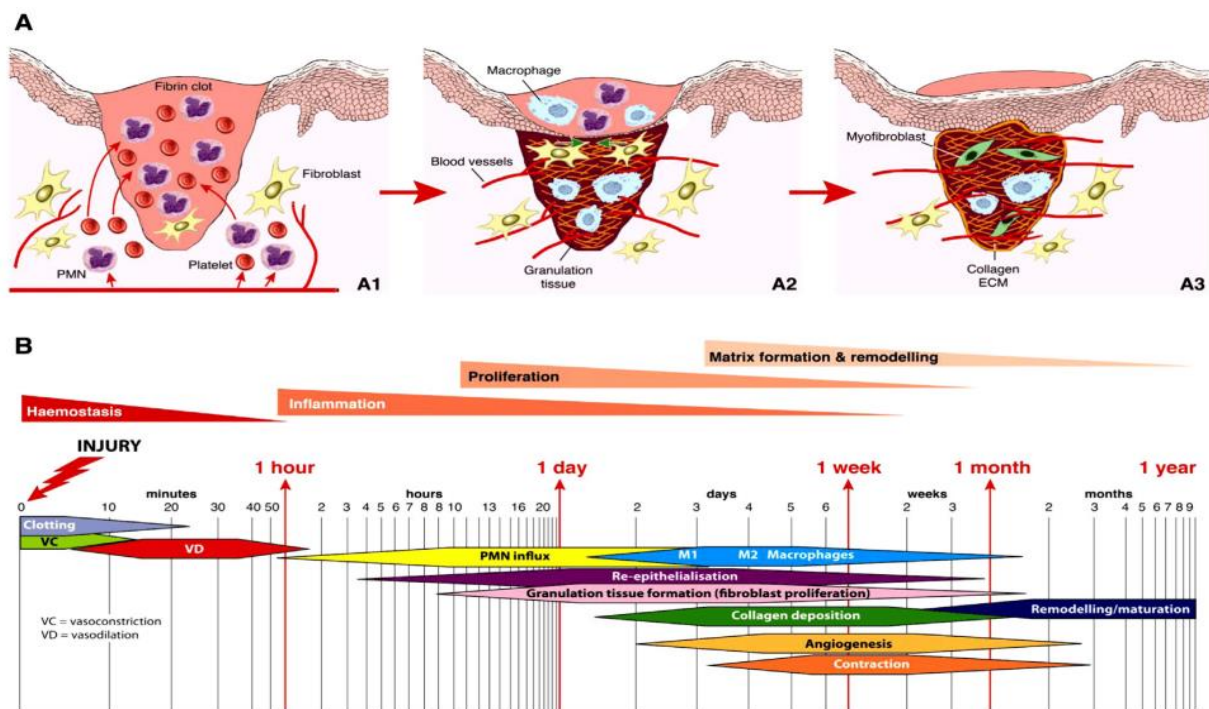


### 3. Aims and objectives

The aim of this review is to provide an alternative perspective to wound management and investigate the influence of Emotional Intelligence on wound healing. Since modern medicine should take a biopsychosocial approach, it is important to consider more conservative treatment options and to integrate a patient's psychosocial precondition into the treatment regime. By analyzing and understanding the Emotional Intelligence of patients, physicians can use it as a tool to influence physiological processes and can make use of it just as equally as pharmacotherapy during patient care. Implementing a patient's Emotional Intelligence in their treatment plan could potentially result in a more cost effective and sustainable treatment and is therefore worth exploring.

### 4. Physiology of wound healing

Wound healing is a very complex and multi-layered process that entails many different processes and mediators working together and in parallel as portrayed in figure 1 (7). Depending on the extension of the wound it can take multiple weeks or even months to fully recover tissue properties. However, Han et. al. (3) say that wounds regenerate to a maximum of 70% in comparison to the preinjury state (3).



*Figure 1: “Overview of acute wound healing. (A) Cellular influence in acute wound healing; (B) overlapping 4 phase model of acute wound healing and its time frame.” (Taken from source 7)*

The healing process can generally be divided into four main phases: hemostasis, inflammation, cell proliferation and tissue remodeling. Each phase has its characteristics, function and mediators which will briefly be explained in the following (2, 7).

*Hemostasis:* This phase is the first phase starting immediately after the injury and lasting minutes to hours depending on the extent of the tissue damage (2). Its goal is to reduce the amount of hemorrhage via vasoconstriction and activation of the clotting cascade (2, 7). A fibrin clot is formed that temporarily closes the wound (8). The details of this phase lie beyond the scope of this paper and will therefore not be discussed in further detail.

*Inflammation:* The immune system plays an essential part in any healing process of the body. Inflammatory processes are important to remove foreign material, recruit appropriate cells and create other important mediators needed for regeneration (2, 7, 9). During this phase an influx of neutrophils and macrophages can be seen into the damaged tissue. Those are key elements during this phase because they are needed for phagocytosis of foreign objects or pathogens, growth factor secretion and other cell recruitment like fibroblasts and endothelial cells (3, 7). It is of great importance that inflammatory processes are tightly regulated by the body because an extended or reduced inflammatory phase could be counterproductive and impair the healing process (2, 8).

*Cell proliferation:* Between two to three days after the tissue damage previously recruited endothelial cells and fibroblasts start to proliferate and generate extracellular matrix (ECM), granulation tissue and increase angiogenesis (2, 3, 7, 8). The wound site starts to regain structure and newly formed vessels can supply the injury site with new cells and nutrients (2, 7).

*Tissue remodeling:* Tissue remodeling is the final stage of wound healing and describes processes that bring the newly synthesized tissue close to its original state. During this phase fibroblasts transform into myofibroblasts, collagen type three turns into collagen type one, epithelialization comes to a closure and finally a scar is forming (3, 7, 8).

Table 1 (2, 7, 8) will give an overview of important immunological mediators and their origin and function during wound healing.

*Table 1: Cytokines and their source and function in wound healing. (Adapted from sources 2, 7, 8)*

<b>Cytokine</b>	<b>Source</b>	<b>Function</b>
Interleukin 1	neutrophils, monocytes, macrophages, keratinocytes	Fibroplasia, leukocyte chemotaxis. Growth factor production, ECM degradation
Interleukin 4	Basophils, mast cells	Fibroplasia, fibroblast chemotaxis, collagen, and ECM production
Interleukin 6	Mast cells, neutrophils	Thrombus resolution, enhances gene expression in macrophages, intracellular signaling in inflammatory cells
Interleukin 10	Neutrophils, regulatory T-cells	anti-inflammatory function
Tumor Necrosis Factor- $\alpha$	Neutrophils, monocytes, macrophages, mast cells, keratinocytes	Fibroplasia, Growth factor production, leukocyte chemotaxis, ECM degradation
Epidermal Growth Factor	Platelets, macrophages, keratinocytes	Fibroplasia, re-epithelialization, leukocyte chemotaxis
Transforming Growth Factor- $\beta$	Platelets, macrophages, fibroblasts, keratinocytes, mast cells	Leukocyte chemotaxis, fibroplasia, angiogenesis, keratinocyte proliferation
Hepatocyte Growth Factor	fibroblasts	Angiogenesis, re-epithelialization, leukocyte chemotaxis
Fibroblast Growth Factor 2	Platelets, keratinocytes, fibroblasts, fibrocytes, macrophages, endothelial cells, dendritic epidermal cell	Fibroplasia, angiogenesis, endothelial cell proliferation, ECM regulation (via matrix metalloproteases)
Platelet derived Growth factor	Platelets, macrophages, fibrocytes	Fibroplasia, leukocyte chemotaxis, angiogenesis, granulation tissue formation

Connective tissue growth factor	Neutrophils, monocytes, platelets, T-cells, fibroblasts	Fibroplasia, angiogenesis, scarring
Insulin-like growth factor	Platelets, fibroblasts, keratinocytes, dendritic epidermal cells, bone marrow mesenchymal stem cell, T-cells	Fibroplasia, keratinocyte survival and proliferation
Vascular endothelial growth factor	Macrophages, endothelial cell, platelets, keratinocytes, fibroblast, myofibroblast, fibrocyte, mast cell,	Angiogenesis, vascular permeability, endothelial cell migration, endothelial cell proliferation
Angiopoietin 1	Fibroblast, myofibroblast	Angiogenesis, blood vessel stabilization, endothelial cell proliferation
Angiopoietin 2	Fibroblasts, myofibroblasts	Angiogenesis, opposes angiopoietin 1
Matrix metalloproteinase	Dermal fibroblasts	Angiogenesis, fibroplasia, collagen degradation, ECM degradation,
Urokinase plasminogen activator	Endothelial cells, keratinocytes, monocytes, macrophages, fibroblasts	Fibroplasia, angiogenesis, fibrin dissolution, ECM degradation, activation of growth factors, activation of matrix metalloproteinases
Tissue plasminogen activator	keratinocytes	Fibroplasia, angiogenesis, fibrin dissolution, ECM degradation, activation of growth factors and matrix metalloproteinases
Plasminogen activator inhibitor	Fibroblasts, epidermal keratinocytes	Fibroplasia, angiogenesis, regulation of plasminogen activators, keratinocyte migration
Platelet factor 4	platelets	Neutrophil recruitment, macrophage recruitment, monocyte differentiation, reactive oxygen species formation

Wound healing is an intricate process, which can be altered by many factors. All phases need to be complete, well-coordinated and in a timely sequence to guarantee proper healing. There are other factors, local and systemic, that can impair the healing process. Local factors could be tissue oxygenation, infections, foreign bodies, or venous insufficiency (3, 8). Systemic factors that can have a negative impact would be advanced age, gender, sex hormones, stress, immunodeficiencies, multiple comorbidities, poor nutritional status, and lifestyle like smoking or alcohol consumption (3, 8). With smoking and alcohol consumption probably being the most known negative impacts on wound healing, they slow down the process by negatively impacting tissue oxygenation and blood supply, downregulating leukocyte function and collagen production and increasing the physiological stress by producing a large number of reactive oxygen species (3).

Tissue oxygenation influences wound healing via the Hypoxia Inducible Factor-1-alpha (HIF-1 $\alpha$ ). HIF-1 $\alpha$  is a transcription factor found in many immune cells of the innate immune system (10). Hypoxic conditions in the injured tissue decrease the degradation of HIF-1 $\alpha$  and therefore elevate local tissue concentration (11). An increase in HIF-1 $\alpha$  concentration results in an intracellular translocation into the nucleus where it forms dimer with the HIF-1 $\beta$  subunit and activates the transcription of numerous proinflammatory genes like VEGF, matrix-metalloproteinase 2 and collagen-propyl-4-hydroxylase (11). HIF-1 $\alpha$  therefore has proinflammatory properties, needed in wound healing, but especially increases macrophage motility, invasiveness, bactericidal effects, and the generation of type 1 macrophages (11).

Since this paper is investigating the impact of Emotional Intelligence on wound healing a more extensive understanding about the effects of stress on wound healing will be of use here. The interaction of all these parts will be discussed later.

## **5. Stress and wound healing**

Stress is “the process through which environmental demands exceed an individuals perceived ability to cope, thereby resulting in affective, behavioral, and physiological changes“ (12). It is widely accepted and researched that stress has detrimental consequences for individuals and can alter our bodies on multiple levels. In the field of psychoneuroimmunology (PNI) the interactions between psychological, neurological, and immunological pathways are researched, thus delivering

a physiological explanation to many known phenomena. Stress dysregulates our immune and nervous system and PNI can therefore give detailed insights on the very complex interactions between those systems (13, 14).

The interactions between stress and wound healing can generally be classified into direct and indirect causes. Indirect causes would be mainly behavioral changes that come with increased perceived stress, like the lack of sleep, lower quality nutrition, lack of exercise, smoking or increased substance abuse (8, 12, 14). Direct causes are the ones this paper will focus on and describe immunological changes within the body (8, 12, 14). The two main mechanisms here are the activation of the Hypothalamic-pituitary-axis (HPA) as well as the activation of the sympathetic-adrenal-medullary axis (SAMA) (8, 12, 14) which leads to an increase in stress hormone levels like adrenocorticotrophic hormone, cortisol, prolactin, and catecholamine (9, 15). HPA and SAMA activation itself are nothing pathological and a necessary response to cope with stress. However, the following will show how certain stressors and a strong activation of those systems can have a negative impact on wound healing.

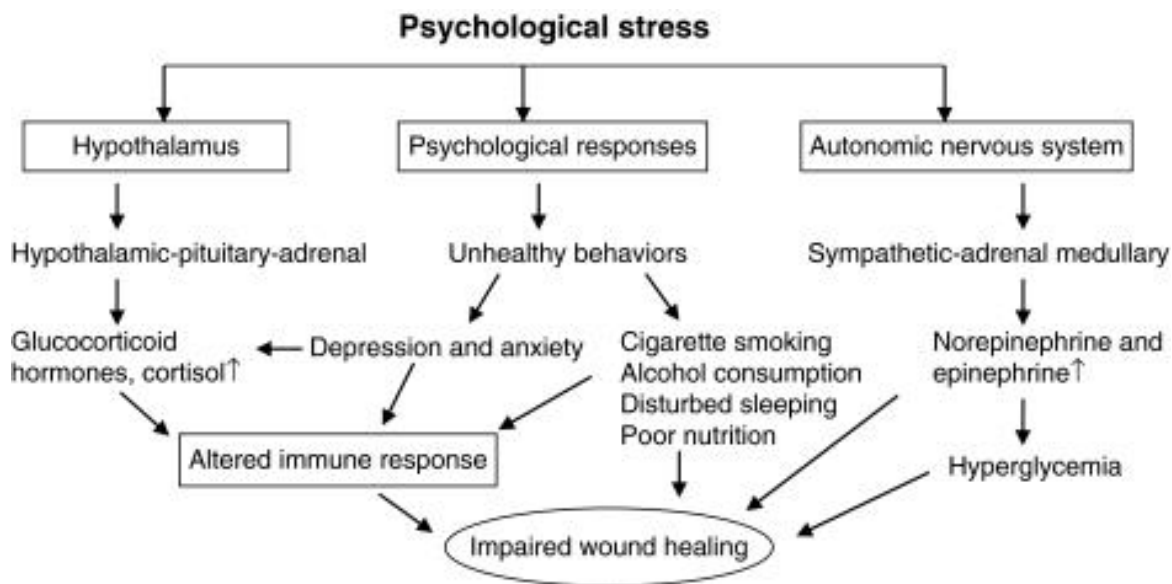


Figure 2: “The effects of stress on wound healing” (taken from source 8)

Existing research has mostly focused on HPA activation and the influence of glucocorticoids (GCs) on wound healing. Increased levels of glucocorticoids have been proven to cause a delay in wound healing and interfere with general cell adhesion, cell trafficking, cell differentiation and proliferation as well as cytokine production (8, 12, 13). Since most immune cells have glucocorticoid receptors on their cell surface, an elevation in cortisol has a very widespread effect (9, 12, 13, 14).

GCs have three main intracellular mechanisms by which they interfere with immune cell function: a) they cause an increase in the nuclear factor kappa B (NF $\kappa$ B) inhibitor, b) they act as a competitive antagonist at the promotor site and, c) they prevent translocation of NF $\kappa$ B into the nucleus (9, 14). NF $\kappa$ B is a transcription factor usually upregulated in inflammation to increase gene transcription and consequently upregulate the production of proinflammatory cytokines needed during those processes (13). Altering the three mentioned mechanisms results in decreased cytokine production which results in lower quantities of TNF $\alpha$ , IL1, IL2, IL6 and, IL8 all factors that are important during the initial inflammatory phase of wound healing as stated in previous sections of this paper (8, 9, 12 - 14). The immune response in general shifts from a TH1 (proinflammatory) response to a TH2 (anti-inflammatory) response with relative elevation in IL10 one of the major anti-inflammatory cytokines usually necessary to keep inflammatory processes under control (9, 14).

Additional cytokines that show decreased levels due to the elevated GC quantities are vascular endothelial growth factor (VEGF), matrix metalloprotease and insulin like growth factor, all important for different stages during wound healing:

Vascular endothelial growth factor is needed for angiogenesis, a crucial process during the proliferative phase of wound healing and needed so new vessels can bring nutrients and cells to the site of injury (2, 7). Matrix metalloproteases are important for matrix production and deposition and especially relevant during the proliferative phase as well.

Inhibited production of insulin like growth factor consequently inhibits proper fibroblast function and proliferation and therefore has an impact during the inflammatory as well as the remodeling phase of wound healing.

Additionally, elevated Glucocorticoid levels have been connected to lower HIF-1 $\alpha$  levels and function (16, 17). Glucocorticoids destabilize HIF-1 $\alpha$  and increase its degradation in the ubiquitin-

proteasome pathway, therefore lowering its intracellular concentration and diminishing its proinflammatory effect (16).

The overall impact stress can have on wound healing and the detailed insight into the different cytokine alterations has been well established with animal as well as human studies over the last decades. Human studies have shown that stress not only alters wound healing but also lowers the immune reaction to vaccines, reactivates HIV and increases the susceptibility to respiratory viruses (12). A study in dental students for example showed a 40% slower wound healing during exam stress than during less stressful times (12, 13, 15). Furthermore, hostile marriages can show their impact by a 60% reduction in wound healing time (13) and caregivers of Alzheimer patients also demonstrated a delay in wound healing by 9 days in comparison to a control group (9, 13). Besides the information about the delay in wound healing, the study on caregivers on Alzheimer patients shows that the biggest difference was seen in the initial phase of wound healing (13). That correlates with the previous stated findings and leads to the conclusion that psychological stress, increased HPA activity and elevated levels of glucocorticoids mostly show their effect by diminishing the inflammatory phase of wound healing (13, 14, 18). An inadequately strong inflammatory phase alters the entire process which relies on tight regulation and coordination.

Furthermore, there are studies that link specific types of stressors to specific immune alterations. For example, anxiety is linked to lower levels of lymphocyte proliferation and IL2 levels whereas shame and guilt seem to mainly alter TNF $\alpha$  quantities (12). Another interesting observation was made regarding surgical stress: While general presurgical stress seems to be associated with lower levels of IL1, specific presurgical worry about the outcomes of the surgery seem to lower matrix metalloprotease levels (12) and general elevated levels of presurgical fear result in longer hospital stay, higher rates of complications and more frequent rehospitalizations (14).

Besides all these negative associations between stress and wound healing there are also some studies that already focus on a potential solution. For example, optimism seems to positively influence wound healing because it increases the number of T-helper cells and elevates Natural Killer cell toxicity (12). Additionally, good social support is linked to lower GC production (in opposition to social isolation which increases GC and therefore delays wound healing) due to elevated oxytocin levels which then limit the HPA response to stress (12, 18, 19). Physical contact can also accelerate wound healing via oxytocin and the above-mentioned mechanisms (19). Some



studies suggest that oxytocin is a marker of stress and is related to higher HPA and sympathetic activity during stressful periods (for example during relationship stress or unsatisfactory social contacts), others show that oxytocin lowers stress levels and HPA activity (18). Therefore, a definite link between oxytocin and the hypothalamic-pituitary-system needs further research and lies outside the scope of this paper.

For now, social interactions seem to be of stronger relevance in females over males which is why no general conclusion can be drawn just yet and further studies are needed (18, 19).

As mentioned above stressors can activate the hypothalamic-pituitary-axis as well as the sympathetic-adrenal-medullary-axis. Whereas for the regulation and downstream processes of stress, the HPA and its connection to wound healing are described and researched in great detail, less insight seems to be gained into the sympathetic mechanisms. The sympathetic part of the autonomic nervous system is directly linked to the immune system via lymphoid organs (12) as well as cell surface receptors (14). Immune cells not only react to glucocorticoid secretion but also catecholamines therefore, the result of SAMa activation can have inhibitory effects on immune cell function (14, 19). However, more research needs to be done in this area to establish a more detailed correlation between the two systems.

## **6. Emotional intelligence**

The term “Emotional Intelligence” (EI) was first used by Mayer and Salovey in the 1990s (20). However, in 1920 Thorndike already differentiated between cognitive and social intelligence, and Wechsler said in the 1940s that there is more than just intellectual factors that are important for overall intelligence (21) showing that the idea of EI is over 100 years old. The Book “Emotional Intelligence” by David Goleman from 1995 made a big impact and has since then been used as a literary reference worldwide (21).

The importance of EI has been established in recent years with many studies showing, that intellectual intelligence, measured via the Intelligence quotient (IQ), cannot fully relate or predict success. IQ alone only relates to about 10-25% in work performance and is an insufficient marker of overall life success (21, 22). Which is where EI becomes relevant. EI can close the gap and is the major reason for life successes (20, 23) and therefore is of significant importance not only for

every individual but also in the field of psychological research. EI is the counterpart to “general Intelligence” which focuses more on cognitive skills (23).

Studies show that high EI is linked to better mental health and a lower risk for depression, anxiety, schizophrenia, substance abuse or borderline personality disorders (21, 23). It can be a protective factor against psychological pathologies and is linked to lower levels of emotional distress. Furthermore, elevated EI is associated with more supportive social relationships, better social functioning, and more successful peer relationships. Lastly, and probably the most researched relation is EI and academic or work-related performance. Many studies relate high EI to increased work-related or academic success (21, 23).

Even though our basic emotional responses are learned early on during childhood development and in response to the main caregiver, EI can be learned and improved (24, 21). There are many different models of learning, for example classroom teaching, discussions, group learning, personal daily journaling, or role play (21). The ability to gain or improve one’s own EI could have further implications since high levels of EI are linked to lower stress levels and better mental health (21).

Besides the increased attention EI has gained over the last decades there still seems to be no consensus about a definition or clear description. A widely used definition and the one that this paper will use is from Mayer and Salovey, where EI is described as “the ability to perceive and express emotion, assimilate emotion in thought, understand and reason with emotion, and regulate emotion in self and others “(20, 21, 23).

The definition by Mayer and Salovey is useful because it already indicates the four main domains that make up EI and which will be briefly explained in the following (21, 23):

*1) emotional awareness and recognition in oneself and others*

Emotional awareness describes the ability to name and recognize emotion in oneself, whereas emotional recognition is in relation to others (23, 24). There are eight basic emotions that are universal and often distinguished based on facial expression: anger, fear, happiness, shame, sadness, love, surprise, and disgust (24).

*2) the use of emotions to facilitate thought and behavior of oneself and others*

Using emotions of oneself and others goes beyond the plain understanding and recognition of them. This domain of EI is focused on prosocial behavioral changes that follow emotional recognition. Emotions can motivate oneself and help us achieve our goals (24) or they can alter our behavior regarding others. Here not just our own emotions but the emotion others are of importance (24). Affective empathy which is described as “the ability to share the emotional state of another person” (23) is necessary to initiate behavioral changes (23, 24).

### *3) understanding and reasoning of emotions*

Understanding and reasoning of emotions describes the ability to understand own emotions and those of others in regard to how they shape and influence behavior (23).

### *4) emotional regulation*

Emotional regulation comprises of the management of one’s own emotion as well as those of others. It is a skill that helps handle relationships and emotions in a way that they can be useful (24). Emotions are useful tools for everyday life but need to be balanced in order to be useful (24).

The underlying physiological or neurological mechanisms of EI are less understood but a meta-analysis of Hogeveen et. al. (23) has tried to connect the different aspects of EI with specific brain centers. The following table 2 will give a brief summary of the emotional domains and their correlating brain centers (23).

*Table 2: The correlation between Emotional Intelligence and associated brain centers. (Adapted from source 23)*

EI domain	Associated brain centers
Recognizing emotion in self and others (emotional awareness=self, emotional recognition= in others)	Awareness: Anterior insula, anterior cingulate cortex, ventromedial prefrontal cortex Recognition: amygdala, ventromedial prefrontal cortex, anterior insula, anterior cingulate cortex
Using emotion to facilitate thought and behavior	Affective empathy: Ventrolateral prefrontal cortex, insula, temporoparietal junctions

	Emotional memory: amygdala > hippocampus, perirhinal cortex
Understanding how emotion shape behavior	Ventromedial prefrontal cortex, (amygdala)
Emotional regulation	Ventromedial prefrontal cortex, ventrolateral prefrontal cortex, amygdala

## 7. Emotional Intelligence and health

Up until now the history, definition, and different components of EI have been explored. As briefly stated above, there is a correlation between elevated levels of EI and health. The following section will try to establish a better understanding of the magnitude of that correlation even though an in-depth analysis regarding this topic lies widely outside the scope of this paper. However, understanding the connection between EI and health in general and possible underlying mechanisms will provide a foundation to the relationship between EI and its effect on postoperative wound healing.

It is thoroughly researched that higher levels of EI relate to better mental health (25) and can lower levels of distress as well as daily stressors and therefore act as a protective factor against psychopathologies (25, 26). Especially in adolescent populations, studies showed a strong correlation between EI and mental health (25). As mentioned previously, EI is able to be learned and improved, with parents being the most significant influence during a child's life. If the parents or major care giver can meet the emotional needs of the child, higher levels of EI are observed (25). A study of unemployed people solidifies the protective characteristics on mental health and showed better management with negative emotions and unhealthy behavior during that time (27).

Besides the benefit in mental health, EI also correlates to better somatic health, better perceived physical health, higher QoL and increased social support (27). It is thought that EI creates better coping mechanisms, more emotional regulation, and proactive behavior, like exercise, healthy diet or supportive social engagements (27).

The four different components of EI (*emotional awareness and recognition in oneself and others, the use of emotions to facilitate thought and behavior of oneself and others, understanding and reasoning of emotions, emotional regulation*) hereby come into play in different magnitudes.

Emotional awareness and recognition in combination with emotional expression and communication have historically been of high interest in psychological research. Whereas modern research seems to focus more on emotional regulation and its specific subcomponents.

A study from 1993 states that the foundation of emotional regulation is emotional communication, which in return relies on emotional expression and recognition (28). Being able to communicate one's emotions is essential for social interactions and therefore for social support which is one of the key mechanisms in how EI is linked to health (28). A lack of emotional expression impedes social communication and therefore emotional regulation (28). Buck R. (28) states that there are three main reactions to emotions: 1) *the physical reaction* (this includes biological changes in the autonomic nervous system, immune mechanisms or neuroendocrine reactions), 2) *the expressive reaction* (which refers to the spontaneous showing of emotions) and 3) *the emotional experience* (meaning the subjective experience of a person to emotions). These three reactions show the complexity and various levels on which emotions influence physical and psychological processes. It is therefore necessary to say that research has yet to establish universal correlations between emotional and physical states. However, there has been a variety of studies over the last 80 years that tried to relate emotions or different personality types with somatic pathologies.

Expressing negative feelings like anger, fear or sadness helps release emotion and has showed success in stress management of cancer patients (29). Feelings like fear, panic, anxiety, arousal or fatigue are linked to increased asthma severity measured by subjective experience of symptoms as well as the peak expiratory flow rate (30). In regard to specific cytokine alterations it was already mentioned that anxiety lowers IL2 levels, shame and guilt lower TNF $\alpha$  quantities and presurgical stress results in decreased levels of IL1 and matrix metalloproteinases (12). Additionally, Grace and Graham linked various personal attitudes with diseases: people that often felt "unfairly treated" showed a higher incident of cutaneous hives, people that describe themselves as always "being on guard" seem to experience more hypertension and people with high levels of hostility or unexpressed anger have a higher risk for cardiovascular diseases (31). Even though the correlations seem to be fairly well established the underlying mechanisms of how emotions alter physiological functions are still under investigation. One interesting case study tried to measure physiological changes in a woman who "tapped into her emotions" on command (31). The most significant observations were the change in heart rate while feeling and expressing disgust and anger. Both

emotions resulted in an increase in heart rate with anger showing the most severe impact by raising the heart rate by up to 80bpm (31). Even though case studies are not reliable data because of the severely limited population size, this case and the above-mentioned studies are examples of how emotional states can influence cardiovascular functions, the immune system and HPA (26). In 1984 Buck said that “high need for power” in men leads to a constant activation of the sympathetic nervous system and therefore alters immune function and results in disease (28). Studies have established that facial expressions as an indication for different emotions result in different autonomic nervous system (ANS) and HPA responses depending on the experienced emotion (31). Alterations in HPA and SAMe have often been used to measure changes in psychological status, since their downstream actions can be measured through levels of catecholamine and cortisol. For example, Giese-Davis et. al. (29) state that chronic arousal first increased the HPA activity and elevates cortisol levels, but later on causes a cortisol downregulation due to compensatory mechanisms and additionally links the expression of positive emotions with lower cortisol levels (29).

Naming, experiencing, and expressing emotions is only one part of EI. The ability to apply one’s knowledge about emotions and regulating them are also important dimensions of EI. Emotional regulation is of special importance because emotional awareness alone doesn’t necessarily increase health. Awareness is the prerequisite for regulation however, hyperawareness indicates negative effects on mental health, proving the necessity of emotional regulation (26). Patients with somatic and mental pathologies have worse emotional regulation and vice versa the ability to use emotional skills daily improves mental and general health (26). Additionally, controlling one’s emotions and expressing them appropriately is essential to function socially, which in return leads to better social support and protection against illness (28).

Emotional regulation describes the management of one’s own emotions as well as those of others (24, 28, 32). It consists of two main mechanisms that have been of interest in modern research: reappraisal and suppression (31, 32). Reappraisal means to change the interpretation of a certain situation and turn it into something more positive. Suppression on the contrary means to simply lower the level of expression of a certain emotion (31, 33). Both have their importance and can be of significance in managing feelings. However, suppression is said to require more energy and is considered “less healthy” than reappraisal (31). The *suppression hypothesis* by Buck from 1984

already linked lower levels of emotional expression to higher stress (28). Studies showed that suppressing an emotion can increase a rise in heart rate two-fold in comparison to just expressing the feeling (31) and is linked to higher cancer incidence and cancer mortality (33). Furthermore, suppression is associated with lower physical and mental health and shows an increased prevalence in depressive symptoms, low self-esteem, less academic success and worse social interactions (32, 34). The underlying mechanisms of how reappraisal and suppression alter physiological functions goes back to changes in the HPA (35). If used in acute situations, reappraisal and suppression elevate cortisol levels (35) indicating a higher energy expenditure and stress response. Whereas suppression shows the same effect in acute and chronic use, reappraisal can lower the stress response and HPA activity when used habitually (35), indicating it as a useful tool in stress management. It is therefore of no surprise that reappraisal is linked to better physical and mental health, memory function, more academic success, and a better social life (32, 34).

Overall, it can be said that EI and specifically emotional awareness, expression and regulation are tightly connected with our body's physiological states. They influence the HPA, SAMe and other immunological mechanisms like cytokine expression, with HPA and SAMe alterations being the most researched ones. Since the body's stress mechanisms alter a variety of physiological mechanisms, the importance of EI in patient care should not be neglected. The beginning of this paper laid out how stress and consequent alterations in HPA and SAMe can influence wound healing by inhibiting the inflammatory response and therefore interfering with a very sensitive system. It can now be concluded that EI can be linked to wound healing via the stress responses of the body and not only gives an explanation to wound healing differences between people but also offers a viable treatment option.

## **8. Discussion-Implications for patient management**

Now that the connection between EI and wound healing has been established, it is of interest to see how that can impact future patient care. Medicine is supposed to be based on a biopsychosocial approach, however, pharmacotherapy and interventions often take a leading role in patient management, whereas psychological support is often neglected. The biopsychosocial concept exists in medicine at least since the 1940s but has mostly been limited to mental disorders (36). This model incorporates biological as well as psychological and social factors when it comes to the etiology of diseases and gives therefore a more holistic approach to the patient. George Engel made a significant contribution to the concept which gained his attention in regard to the effect of psychological influences on gastrointestinal diseases (36). Engel recognized the importance for patient care and disease prevention that a more holistic approach can give (36).

Addressing EI in patients directly and encouraging them to improve their emotional expression and regulation could be a useful method to increase patient health and reduce treatment costs. Even though a big part of one's EI is learned during childhood and from the main caregiver, EI training has shown to be successful in support staff (37). There are many different methods of learning when it comes to EI: didactic training, verbal and video feedback, journaling, group learning, role play, art therapy, music therapy, expressive dance, meditative thinking, or cognitive behavioral therapy (21, 32, 37, 38). Those methods have been proven to help recognize emotions better (37, 38, 39) as well as understanding them better which enables people to manage feelings more easily (37, 39).

Physicians should therefore consider not only implementing some type of EI training into their personal life but also suggest it to their patients. As this paper displays, being emotionally balanced is not only important for mental but also for physical health. Learning skills like habitual reappraisal can therefore be of great health benefit and might improve certain disease courses or prevent disease onset in the first place. Therefore, the goal for a physician should be to approach patient management holistically since “a good attitude and healthy spirit may have positive physical effects” (38).



## 9. Conclusion

Wound healing is a tightly regulated and complex mechanism that plays a key role in patient care and is of medical as well as of economic interest. There are many local as well as systemic factors that can alter wound healing. Local factors could be tissue oxygenation, infections, foreign bodies, or venous insufficiency (3, 8). Systemic factors that can have a negative impact would be advanced age, gender, sex hormones, stress, immunodeficiencies, multiple comorbidities, poor nutritional status and lifestyle like smoking or alcohol consumption (3, 8).

For this paper stress as a direct influence on wound healing was of special importance, because alterations in the physiological stress responses (HPA and SAMe) are the connection between psychological and physical states. Many immune cells have catecholamine and glucocorticoid receptors, explaining their sensitivity to different stress levels in the body. In the mechanisms of wound healing an elevation in cortisol levels results in a decrease in proinflammatory and other cytokines important during the healing process. Altering those cytokines ultimately affects the inflammatory, proliferative and remodeling phase of wound healing and therefore alter the intricate balance of the healing process.

The stress axes of the body therefore bridge the gap between emotional and physical states and give an explanation of underlying mechanisms. EI is a concept that has its origin in the early 20<sup>th</sup> century and is of major importance for social and other life functions. Mayer and Salovey described EI as “the ability to perceive and express emotion, assimilate emotion in thought, understand and reason with emotion, and regulate emotion in self and others” (20, 21, 23). The definition directs us to the four different domains of EI: 1) emotional awareness and recognition of oneself and others, 2) the use of emotions to facilitate thought and behavior of oneself and others, 3) understanding and reasoning of emotions and 4) emotional regulation. Emotional awareness, expression and regulation are linked to many psychological and somatic diseases with the underlying connection being the stress axes of the body. Since modern medicine is supposed to work based on a biopsychosocial concept the EI of patients should not be neglected when it comes to patient care. Implementing EI into patient care will strengthen the doctor patient relationship and bring a more holistic approach to patient management. Generally improving EI but learning the habitual use of regulatory mechanisms like reappraisal could be a significant tool in patient care and should therefore be considered regularly.

## **10. Summary**

This paper explores the importance of EI in patients and its relation to postoperative wound healing.

Wound healing is a tightly regulated and complex mechanism that plays a key role in patient care and is of medical as well as of economic interest. There are many local and systemic factors that can alter wound healing. For this paper stress as a direct influence on wound healing was of special importance, because alterations in the physiological stress responses seem to be the connection between psychological and physical states. Many immune cells are sensitive to stress hormones via cell surface receptors. In the mechanisms of wound healing an elevation in cortisol levels results in a decrease in proinflammatory and other cytokines important during the healing process. The stress axes of the body therefore bridge the gap between emotional and physical states and give an explanation of underlying mechanisms. EI is a concept that has its origin in the early 20<sup>th</sup> century and is of importance for social and other life functions. Emotional awareness, expression and regulation are linked to many psychological and somatic diseases. Since modern medicine is supposed to work based on a biopsychosocial level the EI of patients should not be neglected when it comes to patient care. Improving one's EI and especially learning the habitual use of reappraisal could be a significant tool in patient care and should therefore be considered regularly in patient management.

### **Key words:**

Emotional Intelligence, Wound Healing, Psychoneuroimmunology

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## **Curriculum Vitae:**

Sandra Dinter was born May 6<sup>th</sup> 1994 in Bad Soden a.T. in Germany. She graduated High School/ Gymnasium 2013 and received her Abitur. During her High School years, she became passionate for rowing and successfully rowed at National as well as international competitions, which granted her a sport scholarship with The Ohio State University in Columbus Ohio USA. Sandra attended The Ohio State University from 2013 until 2017 where she obtained her Bachelor of Science (premed) and became a three-time National Champion with her Rowing team.

Medicine has been a passion of Sandras since her teenage years, and she knew early on that she wanted to become a doctor which led her to multiple internships in different medical specialties. In 2018 Sandra started Medical School at the University of Rijeka, Croatia, where she will be obtaining her degree in summer 2024.